VOLUME 7 NUMBER 11

Journal

of the

American Welding Society

November, 1928

Published Monthly
by the
AMERICAN WELDING SOCIETY
33 West Thirty-ninth Street
New York

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JOURNAL

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AMERICAN WELDING SOCIETY

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Subscription $10.00 per year to United States. $11.00 to Canada. Libraries $5.00
Back numbers, per copy: Members, $0.50; Non members, $1.00.

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AMERICAN WELDING SOCIETY
ESTABLISHED 1919
JOURNAL

Volume 7 NOVEMBER, 1928 Number 11

Structural Steel Welding Research

This issue is given over very largely to the Specifications for Test Specimens, their preparation and testing as prepared by the Structural Steel Welding Committee of the American Bureau of Welding. The specifications are divided in a number of sections as follows: (A) General Information. (B) Qualification of Welders. (C) Welding Specifications for Test Specimens. (D) Inspection and Supervision. (E) Design of Test Specimens. (F) Procedure for Testing.

Although the specifications were intended primarily for the use of the committee, in many respects they serve as a guide for the inspection and welding of this type of work.

Considerable progress has already been made by the committee in its work. A digest of existing information and test data was published by the committee in the November, 1927, issue of the JOURNAL. A series of pilot tests were made by the University of Toronto under the auspices of Prof. Peter Gillespie, which have enabled the committee to modify its program and to revise its procedure specifications in certain respects. The results of these pilot tests will be published in an early issue of the JOURNAL. Steel for making the specimens will be donated by three steel companies and the specimens will be made up by some thirty leading fabricating shops and tested in university and governmental laboratories. The funds for the first year's work are in hand. The remaining necessary funds have been pledged. The work of this committee will undoubtedly be instrumental in advancing, by several years, the application of welding in the structural field.

The Cost of Noise

(Reprinted from Oct. 5, 1928, issue Iron Age)

American workmen seem to be deaf to industrial noises; it might almost be said that Americans are deafened by industrial noises. The roar of rapid and powerful machinery, the clanking of hammers and presses, the grinding of gears (still with us), the puffing of engines and the whistling of exhausts, the ringing of bells and shrieking of sirens—all rise into a crescendo so characteristic of industrialism that the modernist composes "music" to its rhythm. We tolerate this bedlam despite the fact that we all avoid mechanical noises in the home, and pay premiums for silent vacuum sweepers, refrigerators, and household appliances, and judge a motor car by its quiet passing. Even though we search for economies in manufacture, we endure violent noises, every one of which represents waste. Would not an efficiency engineer be lost in a factory which, though busy, was quiet?

Perhaps the construction operations in our big cities are no guiltier than other branches of industry elsewhere, but they do seem to proceed with utmost disregard for eardrums—and some of it seems avoidable. Popular opinion and local ordinances have long since demanded mufflers on gas engines, yet an excavator thinks nothing of parking an air compressor alongside the curb, cranking it up, and when it is not blowing off into the throbbing atmosphere, it is pumping air into pneumatic concrete breakers peppering away like so many machine guns.

Such unnecessary noise is doubtless costly. Street railroads, which have been constant offenders, are beginning to realize this. For instance, car noises in San Francisco are being reduced by more precisely cut gear teeth, and the amplification of

such clatter as yet remains is prevented by lead rings inside the gears, sound-absorbing fabric in the car floors, and rubber pads between trucks, bolsters and bodies. Crossings are made of one-piece steel castings, and the wheels ride over on their flanges. This prevents battering at the slots cut in the rail heads; noise is further reduced by imbedding the entire track layout in solid asphalt. The public service company reports that this type of crossing not only prevents resonance from the pavement, and avoids shocks passing through to adjacent buildings, but also is much more economical to maintain and presents a smoother roadway for other vehicles. It is also to be expected that less noisy vibration in the rolling stock will result in lower repair bills.

The cost of construction rackets in big cities is less easy to estimate. But if anyone thinks it is of no importance, let him ask a hotel proprietor alongside an extensive building operation! At the American Welding Society meeting recently it was stated that at least fifty rooms in a Philadelphia hotel had been practically uninhabited for nearly a year on account of the noises from adjacent subway and building construction. This represents a loss of approximately $100,000 income to this one proprietor!

Silent construction is emphasized for welded structural steel erection. For example, as described on another page of this issue, a twelve-story hotel at Hot Springs, Ark., was built between two similar structures without the resounding clatter of rivetting guns, and the extra cost of $8 per ton was undoubtedly justified. The erector said the only improvements he could now suggest would be quiet gears on the hoists and lead faces on the erectors' mauls.

Whether welded erection is inherently more costly than riveted joints may be questioned. Again, it may be true that the compressed air industry may be able to develop a silent squeezer, portable enough for erection purposes. At any rate, it should be a matter of congratulation that so young a process can compete at no greater a handicap with one which is entrenched behind years of engineering practice and trade union domination. When steel designers work out connection details which can be bolted up adequately and easily, yet provide for the necessary welding in the "down" position; when a sufficient number of trained welders is available; when inspectors and building codes understand and provide for the new method, it may be expected that the overall cost of silent erection will decrease.

Our philosophy is that the best is always cheapest. If welded erection is really a better method from an engineering and constructor's viewpoint, it will before long be demonstrated to cost less than the noise we have accepted for so long as a necessary evil. In such an event, the structural trades will adopt welding as a matter of course. But even if welding should always cost more, there will be many places where the silent method will be demanded by a harassed community, despite the extra. It would not be the first time that the value of public convenience and well being has overshadowed minor financial considerations, and hastened the adoption of some revolutionary proposal.

Two Heads Are Better Than One

(Reprinted from Nov. 3, 1928, issue Electrical World)

Engineers are frequently confronted by problems that require for their solution special equipment, freshness in knowledge of theory and abundance of time, any or all of which may be lacking—or let us admit that the first and third items may be lacking and omit a discussion of number two as possibly controversial.

Technical colleges have much special apparatus suitable for research. Some at least of their students are eager to come to grips with reality, to exercise their ingenuity and to apply their knowledge; likewise some, if not all, of the faculty members want to give their more capable students every opportunity in that direction and are willing to devote much time and sincere effort to guiding them. Here, evidently, are two complementary conditions. Plainly, too, it is easier for the engineer who has a problem to solve and lacks the necessary equipment to bring it before a neighboring technical school than it is for the school to go out and find the problem. Examples of such co-

ordination of effort might be drawn from any field of engineering, though they are not so common as they ought to be.

Not every problem lends itself to cooperative research. Some are too abstruse; some require only a study of existing technical literature—books, periodicals and society transactions; some come appropriately within the province of the consulting engineer. But the practitioner who does not on occasion get into touch with his neighboring technical school may be missing more than he realizes. He may be overlooking an opportunity for real service to the prospective members of his own profession, for making a useful contribution to technical progress and, quite possibly, for getting very material help on his own job.

SECTION ACTIVITIES

Boston

On Friday, Oct. 19, at the invitation of the Maine Steel Products Company, members of the Boston Section of the American Welding Society and the Affiliated Engineering Societies motored to South Portland, Me. The occasion was the dedication of the new building of the steel company. This is an electric welded steel building erected entirely without rivets by the Manchester (N. H.) Engineering & Welding Company and used for assembly of welded Sargent highway snow-plows and similar products.

Under the leadership of Thomas A. Wry of Lynn, Mass., Program Chairman Henry O. Westendarp, Secretary H. N. Ewertz and Treasurer H. D. Large the party made the 115-mile trip in about four hours and were welcomed by President George C. Soule of the Maine Steel Products Company, Mayor George H. Minott of South Portland, City Manager James E. Barlow of Portland and many industrial and financial leaders of Portland and the State of Maine.

After an hour's inspection of the many interesting plant operations, the party of some 200 engineers and friends sat down at 4:30 to a fine "Maine-built" clambake and lobster dinner. A boxing match and several stunts enlivened the proceedings.

Then Toastmaster Wry introduced the speakers. In addition to President Soule and the local officials, talks were given by Paul Covey, the constructor of the building; by Don A. Sargent, the snow-plow king, and by Professor Frank McKibben of Black Gap, Pa., consulting engineer of General Electric Company on electric welding.

Mr. Covey stressed the importance of skilled supervision and inspection in the welding of steel buildings. Professor McKibben confirmed this need by indicating he would not hesitate to design a twelve-story welded building at the present state of art.

Professor McKibben pointed out that electric welding is no longer in the experimental stage. Sixty-five buildings have now been erected by the electric arc welding process.

On Nov. 9, the Boston Section held its November meeting. A trip was made through the factory of the General Electric Company River Works Plant to see demonstrations of atomic and arc welding and welding and cutting of steel by city gas.

A two-reel film was shown, entitled, "Electric Arc Welding in Industry." An address of welcome was given by Nelson J. Darling, manager of the River Works of the General Electric Company. The speakers of the afternoon were: Prof. C. A. Adams of Harvard University, who spoke on "What the American Bureau of Welding Is Doing on Research"; D. H. Deyoe of the General Electric Company, on "General Arc Welding"; Royal C. Warring of the Eastern Massachusetts Street Railway Co. spoke on "Railroad Welding and Bonding"; C. A. McCune of the American Chain Company gave a talk on "Testing Welding Wire," and C. K. Tripp of the General Electric Company spoke on "Testing the Strength of Welds."

Another feature of the evening was the projector exhibition showing of arc on screen as it actually takes place on work.

Lunch was served later in the day and another moving picture was shown, entitled "Arc Welding Pipe Line." The speakers of the evening were: Fred Davis of the General Electric Company, who spoke on "Atomic Welding"; J. W. Owens of the Newport News Shipbuilding and Dry Dock

Company, on "Shipbuilding by Arc Welding Process;" and W. Irby of the General Electric Company, who spoke on "City Gas Welding and Cutting." These were all very interesting papers.

Chicago

On Friday, Nov. 2, this section held a very interesting meeting. George Rose of the Oxweld Acetylene Company addressed the Chicago Section on "Oxy-Acetylene Welding of Steel." This was an excellent paper and a profitable one. Two films from the Goodyear Tire & Rubber Company were shown. They were "The Story of Goodyear" and "Conquering the Jungle."

Philadelphia

The Philadelphia Section will hold its next meeting on Nov. 19. E. Joyce, associate metallurgist, will talk on "Welding in the U. S. Naval Aircraft Factory." The meeting will be held in the Auditorium of the Engineers Club, 1317 Spruce Street.

Cleveland

On Jan. 14 to 18, inclusive, 1929, the Western Metal Congress, Los Angeles, will take place, under the auspices of the American Society for Steel Treating, 7016 Euclid Avenue, Cleveland, Ohio. On Jan. 14 to 18, inclusive, 1929, the Western States Metal and Machinery Exposition, Shrine Auditorium, Los Angeles, will also take place, under the auspices of the American Society for Steel Treating.

San Francisco

The first meeting of the San Francisco Section was held on Nov. 16. Prof. Charles Moser of Leland Stanford University reported on his trip to the Fall Meeting of the American Welding Society held at Philadelphia last month. J. C. Bennett presented a paper which was a review of the revised "Air Tank Code of the California Industrial Accident Commission." Hugh Brown, of Brown Bros., presented two reels of moving pictures, entitled "Welding Conduit Pipe for the Feather River Power Project." Mr. Brown described some of the problems they have overcome in this big welding job. An ingenious device was developed in the shops of Brown Brothers for use in cutting pipe on this job. This was also shown and described by Mr. Brown during his talk.

Portland

The Oct. 4 meeting of this section took place at the Multnomah Hotel. Mr. Heacock of the Linde Air Products Company presented a paper prepared by his company, entitled "What the Oxy-Acetylene Process Means to the Refrigerating Industry." The discussion was illustrated with slides, and showed the enormous advantages of welded fittings as compared to screwed connections both from ease of installation and maintenance.

A general discussion followed the address. Mr. Davis of the Northwestern Ice and Cold Storage commented on the use his own organization made of welding. Mr. Wharmby, in charge of pipe line installation for the British Columbia Gas & Electric Company, discussed the use of welded connections in gas pipe lines. Nearly every one took part in this general discussion making the meeting one of the most interesting held by the Section.

Western New York

On Thursday, Nov. 15, this section held a meeting. J. Norman Wilson, master mechanic of the Donner Steel Company, presented a paper on "Welding in the Steel Mill as Applied to Maintenance of Equipment." This was a very interesting paper.

New York

The New York Section will hold its November meeting on the 20th. At this meeting there will be election of section officers. The subject for this evening will be "Special Monel and Nickel Welding Jobs," which will be presented by R. J. McKay and J. G. Schoener, of the International Nickel Company. This talk will be accompanied by lantern slides. Discussion will be welcome. A moving picture consisting of three reels will be shown. The first of these, entitled "Oxwelding and Cutting—the Modern Method of Joining and Severing Metals," which shows, by means of animated drawings, the operating principles of oxy-acetylene equipment. Reels two and three, entitled "Oxwelding and Cutting in Production," show how the oxy-acetylene process is used in the manufacture of a variety of products, including automobile bodies, airplane fuselages, pressure vessels, transformers and Diesel engine.

AMERICAN BUREAU OF WELDING

An Advisory Board on Welding Research and Standardizing of the American Welding Society and the Division of Engineering of the National Research Council

STRUCTURAL STEEL WELDING COMMITTEE

Specifications
for
Test Specimens
Their Preparation and Testing

Contents

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(A) General Information
(B) Qualification of Welders
(C) Welding Specifications for Test Specimens
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(E) Design of Test Specimens
(F) Procedure for Testing Test Specimens

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AMERICAN BUREAU OF WELDING

STRUCTURAL STEEL WELDING COMMITTEE

Specifications for Test Specimens, Their Preparation and Testing

SECTION (A)—GENERAL INFORMATION

Purpose

The Structural Steel Welding Committee of the American Bureau of Welding was organized for the purpose of obtaining reliable information upon which safe unit working stresses in the designing of welded structures could be based.

The committee has studied all of the available literature which gives results of tests on welded joints from which unit working values could be deduced. These data were summarized and published in the November, 1927, issue of the Journal of the American Welding Society. It was found that the data were insufficient to form a basis for the establishment of standard working stress values.

The committee, therefore, decided that further tests were needed that would:

1. Confirm or qualify previous results by the use of a larger number of specimens, and a more uniform system of testing.
2. Supplement the scope of previous data by tests on additional forms of joint.
3. Determine what degree of uniformity in commercial welding may be expected.

Program

The present program covers 57 forms of joint in 191 sizes welded by the gas or the arc process, which are presented in Section E. The specimens are of elemental type and embrace fillet welds of lap and tee form, end and edge butt welds, and special joints. Single and double lines of weld, normal, parallel and diagonal to direction of stress, continuous and intermittent, are specified. Entire members may be considered later.

Specimens are to be subjected to static tests for ultimate strength, yield point and ductility, as will be promulgated in Section F. These may be supplemented by dynamic and other special tests. The general aim has been to proportion specimens so that they will fail in the joint and thus indicate unit weld strength, but

for check purposes a few types are included that will probably fail in the base metal.

In order to determine what degree of uniformity may be expected in commercial practice, multiple specimens of each type and size are to be scheduled, whose preparation will be distributed among about thirty-six representative fabricating shops throughout the United States and Canada. Operations will be governed by uniform procedure and inspection regulations. An important part of the program will be the keeping of record as to the sufficiency of these regulations.

Caution

The committee emphasizes the fact that the specifications covered by Sections B, C, D and F are intended to apply *to this investigation only*. Upon completion of the investigation, the experience gained therein is expected to make possible the preparation of a standard code that will furnish the structural steel industry with a reliable basis for designing and making the more usual forms of welded joint along commercial lines.

Acknowledgment

Acknowledgment is made to the many investigators whose research has contributed to this program. Notably should be mentioned Professor Peter Gillespie who, under the auspices of the University of Toronto, made several hundred pilot tests to meet the special needs of the committee.

Allocation

SHOPS* will be advised by the Secretary of the Committee in regard to the range of specimens allocated to each SHOP, the Mill or Warehouse that will furnish the steel for these specimens and the Testing Laboratory to which all coupons and specimens shall be shipped. The procedure governing the procurement of the steel for these specimens will be issued by the secretary of the committee.

Supervision and Inspection

Competent inspectors will be appointed by the Sub-Committee on Procedure, whose duty it shall be to conduct the Qualification Tests and to inspect the welding of the Test Specimens. Standard Inspection Forms have been prepared for the several phases of this work. Inspectors will be provided with "Instructions," Section (D), setting forth recommended Welding Practice, both for the Metal Arc and Gas processes, and Inspectors' duties.

*Shops applies to those structural steel fabricating shops that will participate in the welding of the Test Specimens.

Qualification

Welders designated by SHOPS to participate in the work of welding Test Specimens will be required to pass certain Qualification Tests before they shall be permitted to do any welding on the Test Specimens. These tests are set forth in Section (B).

Welding

Specimens are to be prepared and welded in accordance with the general specifications given in Section (C), and the specific instructions in Section (E).

Testing

Procedure for testing coupons as well as specimens will be promulgated by the Sub-Committee on Laboratory Testing in Section (F).

AMERICAN BUREAU OF WELDING

Structural Steel Welding Committee

Specifications for Test Specimens, Their Preparation and Testing

SECTION B—QUALIFICATION OF WELDERS

Part 1

Direct Current Metal Arc Process*

Procedure to be used for Testing or Qualifying Welders contemplating participation in the work of welding the Test Specimens.

Inspector's Notes:

The following sections (a), (b) and (c) set forth the recommended procedures for qualifying the metal arc welders designated by the SHOPS** to weld the Test Specimens. It may not be necessary to apply test (a) for reasons obvious to the inspector. This test is recommended for welders whose experience may be limited or whose work has been of a different nature than that involved in the Test Specimens. All welders designated by SHOPS for this work must, however, pass tests (b) and (c) before being permitted to perform the welding of any of the Test Specimens.

Each participating shop shall prepare the qualifying specimens for welding by machine tools*** only, in accordance with the specifications herein. The tolerance or allowable variations of the angle of beveling shall be 5 deg., plus or minus. That is, the total bevel shall be between 70 and 80 deg. A tolerance of 1/32 in. shall be allowed in the shoulder dimensions (see Fig. 4). The welding electrode shall conform to the American Welding Society Class E1A or E1B, bare welding wire specifications.

The plates shall be tacked as shown on the drawings or clamped so as to insure the two plates remaining in the same plane after welding.

Where more than one layer of weld metal is specified for a joint, the surface of each deposited layer shall be carefully cleaned of scale, either by a stiff wire brush or by chipping.

Inspector shall fill out the Form 100 (page 16 this section) in triplicate, obtaining SHOP approval, either of the welding Supervisor or General Superintendent, and forward one copy to the laboratory, one copy to the secretary of the Structural Welding Committee, leaving one copy with the SHOP.

---

*These specifications have been prepared for direct current metal arc welding. It is not the intention of the Committee to exclude carbon arc or A. C. welding and those fabricators who wish to use either of these processes may do so providing a procedure specification is submitted to the Committee showing exactly how the selected process is to be used.

**Shops applies to those structural steel fabricating shops that will participate in the welding of the Standard Test Specimens.

***Shaper, planer, or milling machine.

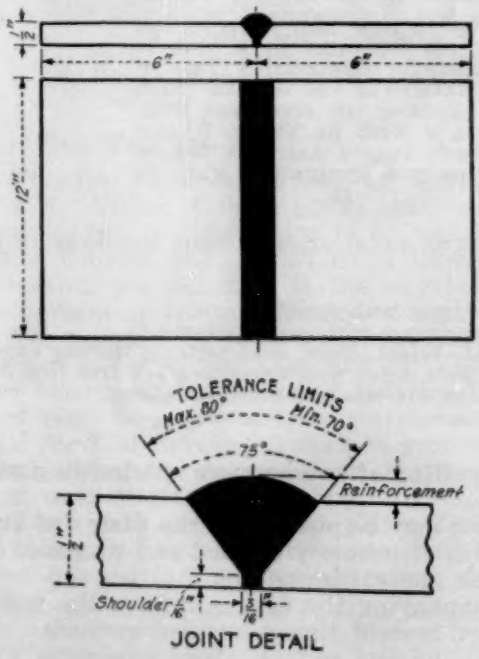
The qualification tests are described herein under the index (a), (b) and (c):

(a) Preliminary observation test
(b) Fillet weld test
(c) Butt weld test

(a) Preliminary Observation Test. (Butt Weld.)

This test requires the welding of one or more specimens similar to Fig. 1. The material may be pieces of scrap plate (of average Structural Steel Quality) if properly cleaned and prepared for welding as specified herein. The plates shall be welded in a flat position, that is, the specimens are to be laid flat on a table or other suitable support. The specifications accompanying the figure inform the welder of what is desired in regard to weld dimensions and methods. The Welding Inspector or Supervisor shall look for the following factors in manual skill, (a) to (d) inclusive, of the welder and shall determine whether he has sufficient skill to proceed with the Qualification Tests (b) and (c).

(a) The holding of a short arc.
(b) Proper penetration and fusion.
(c) Proper current.
(d) Regular movement of the electrode.



JOINT DETAIL

FIG. 1

Specifications for Figure 1

Single "Vee" Butt Joint Welded One Side Only

Number of Weld Layers—2

Amperes average—200

Penetration — fusion is required completely through at the bottom of the plates

Reinforcement—20% plate thickness

Size of Electrode —3/16"

Upon completion of welding and cooling of these specimens, 2-in. wide coupons shall be cut therefrom (gas cutting permitted) in the manner indicated in Fig. 2 and each placed vertically in a bench vise so that the top of the vise jaws grips the center line of the weld. By striking the upper end with a sledge, the coupons are to be bent at the weld until fracture occurs through the weld if possible. (See Fig. 28).

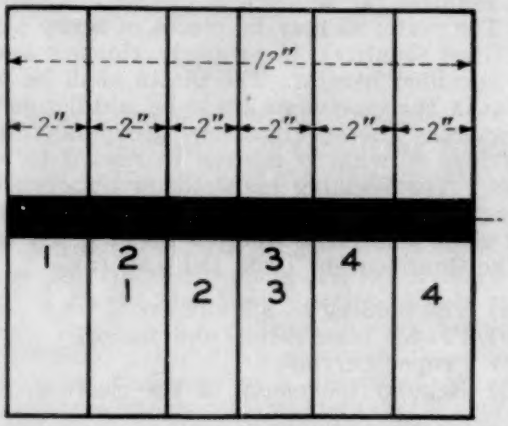


FIG. 2—SHOWING HOW TEST COUPONS ARE TO BE CUT FOR BREAKING IN A VISE TO MAKE PRELIMINARY OBSERVATION TEST OF THE QUALIFICATIONS OF THE WELDER. NOTE THAT ONLY FOUR OF THE SPECIMENS NUMBERED 1, 2, 3, 4 NEED BE TESTED UNLESS SOME DOUBTFUL POINTS ARISE, IN WHICH CASE ALL OF THE SPECIMENS MAY BE TESTED

Inspection of the fractured metal of specimens breaking in the weld shall be made for

(a) Penetration in accordance with specifications.
(b) Reinforcement in accordance with specifications.
(c) Appearance of metal—bright, dense, even textured, fibrous appearing or crystalline weld metal, irregularly torn and free from blow holes, slag inclusions, overlaps and iridescent colors.

(b) Fillet Weld Test

This test requires the welding of two or more specimens similar to Fig. 3.

The material for this test may be pieces of scrap plate (of average structural steel quality) if properly cleaned and prepared for welding as specified in this general procedure.

The specifications accompanying the figures inform the welder of what is desired in regard to weld dimensions and methods:

Upon completion of welding and cooling, these specimens shall be torn apart by driving a suitable wedge between the plates at the

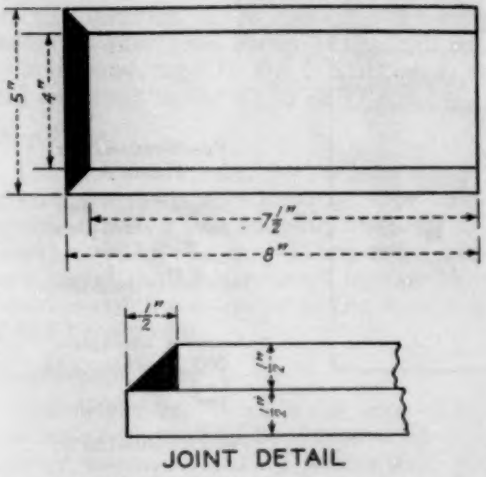


FIG. 3

Specifications for Figure 3

Reinforcement—none, surface straight as shown.
Penetration — fusion is required well into the corner (root).
Number of layers—two.
Amperes (average)—200.
Specimens to be laid flat on a table so that welds will be made in a flat position.
Size of Electrode—3/16".
The two bars shall be "clamped" together for welding.

unwelded end, thus bending the parts at the weld until rupture occurs at this point.

Inspection of the fractured metal of specimens broken through the weld shall be made for

(a) Dimension of fillet in accordance with specifications.
(b) Bright and dense, even textured fibrous appearing or crystalline weld metal, irregularly torn and free from blow holes, slag inclusions, overlaps and iridescent colors.
(c) Fusion of deposited metal with base metal.
(d) Degree of penetration into the right angle corner of fillet (root of weld).

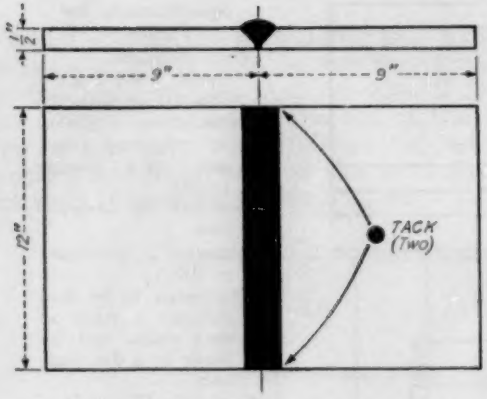
(c) Butt Weld Test

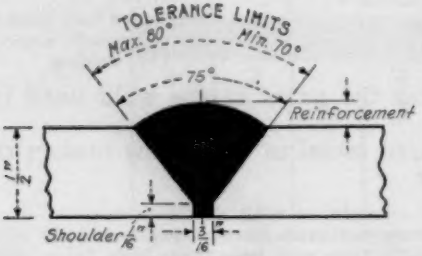
This test requires the welding of five (5) test plates similar to Fig. 4. Three of these plates shall be welded in a flat position, that is, the specimens are to be laid flat on a welding table or other suitable support. Two of these plates shall be welded in a vertical position, that is, the longitudinal axis of the joint is to be upright or vertical during welding.

The material for these final welded test plates shall be of a grade known as Structural Steel and shall conform to the specifications for base metal as provided for the Test Specimens, which see, *and shall be procured from warehouse in same manner as material for Test Specimens shall be procured.* The specifications accompanying the figure inform the welder as to welding practice and weld dimensions desired.

From each of these test plates, four (4) Standard American Welding Society* Test Coupons shall be cut as shown in Fig. 5, and shipped to a testing laboratory, designated by the Secretary

*See Bulletin No. 1 American Bureau of Welding; also A. S. T. M. Standards A7-24, A8-24, A9-24, etc., and A. S. T. M. Tentative Standard E8-25T. The essential dimensions are, width of reduced section 1½ in., length 9 in., ends 2 in. wide and about 3 in. long. Fillet radius between 1 and 3 inches.





JOINT DETAIL

FIG. 4

Specifications for Figure 4

Single "Vee" Butt Joint Welded One Side Only

Number of weld layers —two.

Amperes average—
200 in flat position.
175 in vertical.

Penetration—100%.
Reinforcement—
20% of Plate Thickness.

Size of Electrode—
3/16".

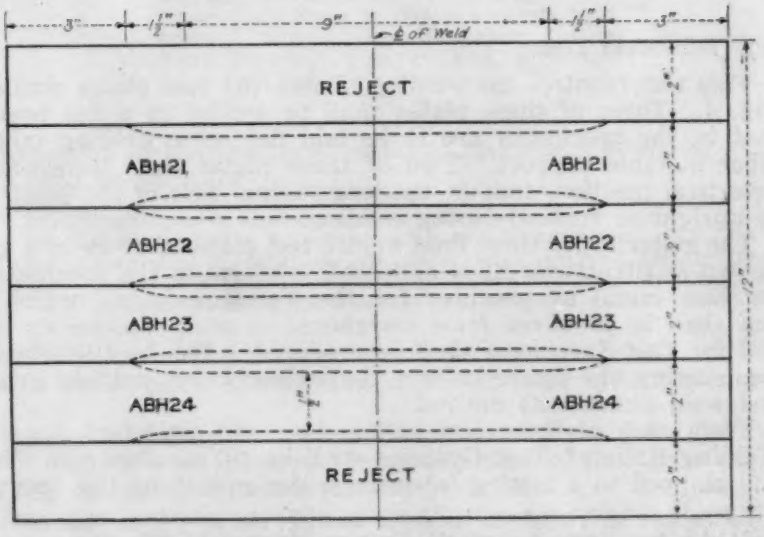


FIG. 5—DIMENSIONS OF COUPONS TO BE CUT FOR QUALIFICATION TEST OF WELDERS AND SENT TO THE LABORATORY FOR TESTING

for the district, to be tested for tensile strength. A log of the observed data (see Form 101) shall be filled out in triplicate and be sent, one copy to the SHOP, one copy to the LABORATORY and one copy to the COMMITTEE.

Shop Note

The plain coupons, 18 in. long by 2 in. wide, shall be removed from the test plate by sawing or by cutting by the shops with a gas cutting torch. The coupons shall then be machined to the dimensions shown in Fig. 5, and any reinforcement of the weld above the base metal shall be removed by machining or grinding, so that the thickness of the coupons at the weld shall not exceed the thickness of the base metal.

Identification Marks

Before the test plate is cut into coupons, a mark identifying the particular plate shall be stamped on each of the four coupons, each side of the weld,* using letters and numerals not less than $\frac{3}{8}$ in. high. It is obviously important to see that all samples are marked *clearly, carefully* and *accurately*. An explanation of the identifying mark, with a sample case, is given below.

A	LETTER FOR SHOP DESIGNATION
B	LETTER FOR WELDERS IDENTIFICATION
V	POSITION OF THE PLATE DURING WELDING— V-VERTICAL; H-HORIZONTAL
1	NUMBER OF THE TEST PLATE
—	COUPON NUMBER

WELDER "B" FROM SHOP "A" SHALL HAVE AT LEAST 5 PLATES MARKED ABH1, ABH2, ABH3, ABV1, ABV2. THE COUPONS TAKEN FROM THESE PLATES WOULD ALSO BE NUMBERED AS ABH21, ETC.

Required Tensile Strength

The average tensile strength of all the coupons shall not be less than 45,000 lb. per square inch and the tensile strength of any one coupon shall not be less than 40,000 lb. per square inch. These values are fixed only for the purpose of qualifying welders, and are not intended to furnish a basis for safe working unit stresses. The coupons shall be tested on a testing machine, which has been checked for accuracy, and the speed of the movable head of testing machine shall not exceed $\frac{3}{8}$ in. per minute until after yield point has been reached. Ultimate tensile strength and appearance of fractured specimen shall be recorded.

*Identification marks should be so placed that they will not be defaced in grips of testing machine or cause premature failure of specimen. Position of marking shown in Fig. 12 required.

Form 101

Inspectors' Form for Qualifying Tests
Metal Arc Welding Process

WELDERS IDENTIFICATION				
TYPE OF QUALIFICATION TEST		a	b	c
POSITION OF SPECIMEN DURING WELDING	Horizontal			
	Vertical			
RATE OF WELDING IN FEET PER HOUR	Horizontal			
	Vertical			
DATES OF TEST				
NUMBER OF COUPONS TAKEN				
WELDING WIRE	Trade Name			
	Diameter in Inches			
ARC WELDING MACHINE DC check AC check	Make			
	Type			
	Size			
ARC CHARACTERISTICS DC check AC check	Average Amperes			
	Average Volts			
REMARKS				

NOTE: Under REMARKS, shall be noted any irregularities that might occur or develop during the tests, such as defective base metal, improper welding arc, fluctuating current, lapping of plates due to improper spacing, non-continuity of welding, etc.

NOTE: PLATE IDENTIFICATION FOR "c" SPECIMENS. Each coupon in each plate shall be marked on both ends as follows:

First letter is to be the Shop Designation.

Second letter is to be the Welders Designation. These letters, assigned by the Inspector, shall be A, B, C, etc., depending upon the number of welders assigned by the shop to the work.

Third letter is to show by H or V whether the specimen has been welded in a horizontal (flat) or vertical position.

The number at the end is to identify the sequence in which the specimen was welded, the first plate bearing the number 1, the second 2, etc.

Therefore, with Welder B from Shop "A" welding the second specimen of the "c" test horizontally the coupons cut therefrom would bear the identification ABH21 to ABH24.

Part 2

Gas Process

Procedure to be used for Testing or Qualifying Welders contemplating participation in the work of welding the Test Specimens.

Inspectors' Notes:

The following sections (d), (e), (f) and (g) set forth the recommended procedures for qualifying the gas welders designated by the SHOPS* to weld the Test Specimens. It may not be necessary to apply Tests (d) and (e) if the inspector believes that the welder will pass tests (f) and (g). They are recommended for welders whose experience may be limited or whose work has been of a different nature than that involved in the Test Specimens. All welders designated by SHOPS for this work, must, however, pass Tests (f) and (g) before proceeding with the welding of the Test Specimens.

In preparing the base metal for Qualifying Tests (d), (e) and (f), the oxy-acetylene cutting torch may be used provided the cut faces are reasonably even and the beveling (if done) is within 10 deg. plus or minus, of specifications. For Qualifying Test (g) the preparation of the joint for welding shall be done with machine tools.** A tolerance of 1/32 in. will be allowed in the shoulder dimension (see Fig. 11) and 5 deg. either way from specified angle of bevel.

If, in the opinion of inspector, a welder, who having failed to qualify for the welding of Test Specimens, can be developed within a reasonable time*** to a point where he can qualify, the committee recommends that inspector give the proper instruction to the welder or "SHOP management" and at the lapse of said reasonable time, again check the welder as described above.

Inspector shall fill out the Form 100 (page 16 this section) in triplicate, obtaining SHOP approval, either of the welding supervisor or general superintendent, and forward one copy to the laboratory, one copy to the secretary of the Structural Welding Committee, leaving one copy with the SHOP.

The Filler or Welding Rod used in the Qualifying Tests shall be of a grade that will develop a minimum tensile strength of 56,000 lb. per square inch in tension in a butt weld joining two (2) mild-steel plates.

(d) Preliminary Observation Test (Butt Welds)

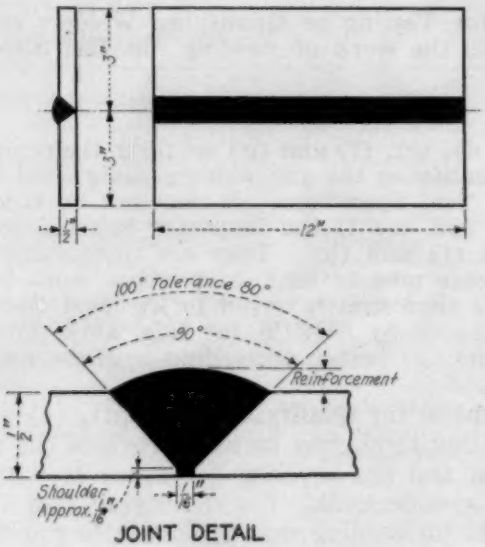
This test requires the welding of one or more specimens similar to Fig. 6. The material may be pieces of scrap plate (of average structural steel quality) if properly cleaned and prepared for welding as specified herein. The specifications accompanying the fig-

*SHOPS applies to those structural steel fabricating shops that will participate in the welding of the Standard Test Specimens.

**Shaper, planer, or milling machine.

***A reasonable time may be considered 10 days to 2 weeks.

ure inform the welder of what is desired in regard to weld dimensions and methods.



JOINT DETAIL

Fig. 6

Note: Plates shall be firmly clamped to a suitable table. In spacing the joint for welding, an allowance must be made at the opposite end of the joint to that where the welding is started to provide for contraction, for otherwise the joint edges along the 1/16" shoulder will overlap before the weld is completed. An additional spacing of between 3/16" and 5/16" is necessary, depending on the rate and method of welding.

Specifications for Figure 6

Single "Vee" Welded One Side Only

Method of Welding Forward or Backward.

Reinforcement—20% of plate thickness.

Penetration — (Full or 100% approx.)

Width of Finished Weld—2½ times plate thickness.

Speed — For ½" metal—Not Under 2 ft. per hr. (flat), 1¼ (vertical).

Position of Specimen for Welding—Flat or Vertical.

The welding inspector or supervisor shall look for the following factors of manual skill, (a) to (j) inclusive, of the welder and shall determine whether he has sufficient skill to proceed with Vise Tests No. (e) and No. (f).

(a) A clean welding tip.
(b) Soft neutral welding flame, neither pointed nor irregular.
(c) Penetration.
(d) "Floating out" of oxides.
(e) Even fusion into the base metal.
(f) Regular movement of the torch.
(g) Occasional check of the neutral flame by throttling back to neutral a momentary excess of acetylene.
(h) Uniform incorporation of filler material with the molten puddle.
(j) Maintenance of clean, bright molten metal in the weld puddle.

(e) Preliminary Vise Test (Butt Welding)

This test requires the welding of one or more specimens similar to Fig. 7 or Fig. 8. The material for this test may be pieces of scrap plate (of average structural steel quality) if properly cleaned and prepared for welding as specified herein. The specifications accompanying the figures inform the welder of what is desired in regard to weld dimensions and methods.

Specifications for Figures 7 and 8

Single "Vee" Welded from One Side Only

FIG. 7

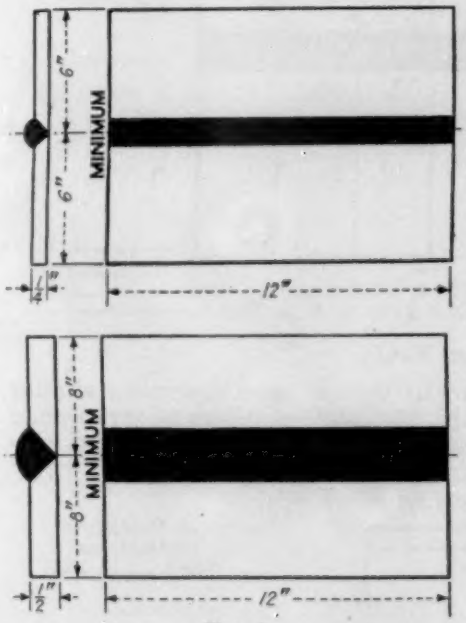


FIG. 8

FOR TYPICAL JOINT PREPARATION SEE FIGURE 6

Method of Welding—Forward or Backward.

Reinforcement—20% of plate thickness.

Penetration—(Full or 100% approx.).

Width of Finished Weld—2½ times plate thickness.

Speed—Not less than For ¼" metal—4 ft. pr. hr. (flat). For ½" metal—2 ft. per hr. (flat). 1½ (vertical).

Specimens to be welded in the flat position.

Note: Plates shall be firmly clamped to a suitable table. In spacing the joint for welding, an allowance must be made at the opposite end of the joint to that where the welding is started to provide for contraction, for otherwise the joint edges along the 1/16" shoulder will overlap before the weld is completed. An additional spacing of between 3/16" and 5/16" is necessary, depending on the rate and method of welding.

Upon completion of welding and cooling of these specimens, 2-in. wide coupons shall be cut therefrom (oxy-acetylene cutting permitted) in the manner indicated in Fig. 9 and each placed in a bench vise so that the top of the vise jaws grips the center line of the weld longitudinally. By striking the upper end with a sledge the coupons are to be bent at the weld until fracture occurs through the weld if possible. (See Fig. 28.)

Inspection of the fractured metal of specimens breaking in the weld shall be made for

(a) Penetration in accordance with specifications.
(b) Reinforcements in accordance with specifications.
(c) Bright and dense, even textured fibrous appearing or crystalline weld metal, irregularly torn and free from iridescent colors.

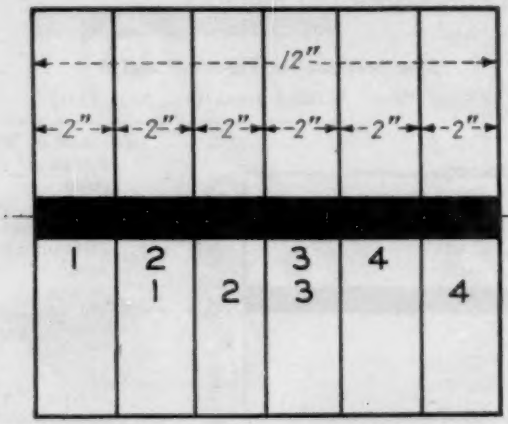
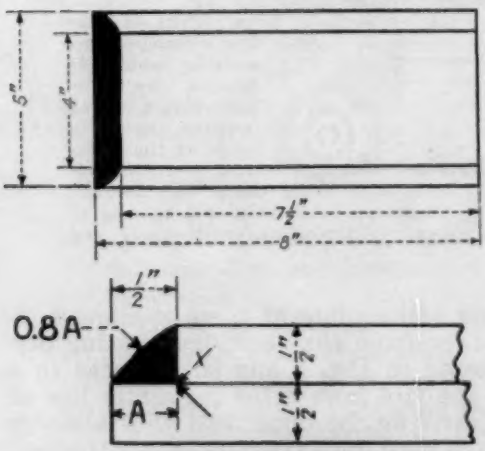


FIG. 9—SHOWING HOW TEST COUPONS ARE TO BE CUT FOR BREAKING IN VISE TEST

(f) Preliminary Vise Test (Fillet Weld)

This test requires the welding of two or more specimens similar to Fig. 10. The material for this test may be pieces of scrap plate (of average structural steel quality) if properly cleaned and pre-

Specifications for Figure 10



JOINT DETAIL

FIG. 10

Method of Welding—One forehand, one backhand.

Reinforcements—As shown.

Penetration—As full as possible, to X corner or "root" of weld.

Width of Weld When Finished—as shown.

Speed — Immaterial, as specimen is too short.

Specimens to be welded flat.

Clamp to hold securely.

pared for welding as specified herein. The specifications accompanying the figure inform the welder of what is desired in regard to weld dimensions and methods.

Upon completion of welding and cooling these specimens shall be torn apart by driving a suitable wedge in at the unwelded end, thus rotating the parts about the weld until rupture at this point occurs.

Inspection of the fractured metal of specimens broken through the weld shall be made for

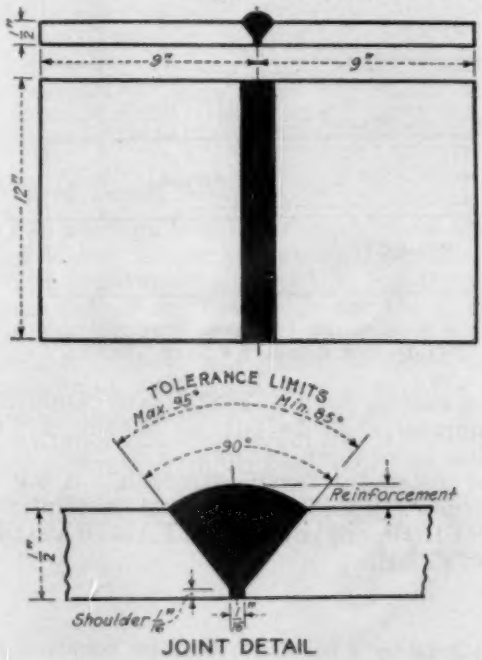
(a) Reinforcements in accordance with specifications.
(b) Bright and dense, even textured fibrous appearing or crystalline weld metal, irregularly torn and free from iridescent colors.
(c) Fusion of the deposited metal and the base metal.
(d) Degree of penetration into the right angle corner of fillet ("root" of the weld).

(g) Laboratory Coupon Test

This test requires the welding of five (5) test plates similar to Fig. 11. Three of these plates shall be welded in a flat position,

Specifications for Figure 11

Single "Vee" Weld from One Side Only



Method of Welding—Forward or Backward.

Reinforcement—20% of plate thickness.

Penetration — (Full or 100% approx.)

Speed—For ½" metal —not less than 2 ft. per hr. (flat). 1½ (vertical).

Width of Finished Weld.—2½ times plate thickness.

Note: Plates shall be firmly clamped to a suitable table. In spacing the joint for welding, an allowance must be made at the opposite end of the joint to that where the welding is started to provide for contraction, for otherwise the joint edges along the 1/16" shoulder will overlap before the weld is completed. An additional spacing of between 3/16" and 5/16" is necessary, depending on the rate and method of welding.

FIG. 11

that is, the specimens are to be laid flat on a welding table or other suitable support. Two of these plates shall be welded in a vertical position, that is, the longitudinal axis of the joint is to be upright or vertical during welding.

The material for these final welded test plates shall be of a grade known as structural steel and shall conform to the specifications for base metal as provided for the Test Specimens, which see, *and shall be procured from warehouse in same manner as material for Test Specimens shall be procured.* The specifications accompanying the figure inform the welder as to welding practice and weld dimensions desired.

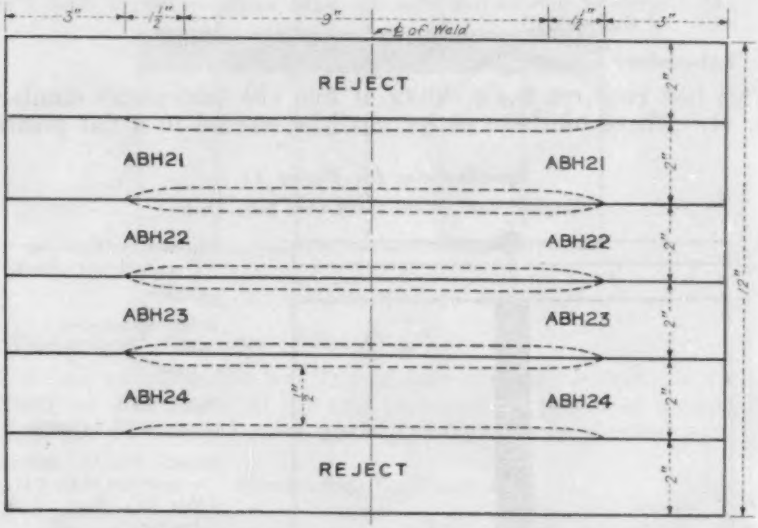


FIG. 12—DIMENSIONS OF COUPONS TO BE CUT FOR QUALIFICATION TEST OF WELDERS AND SENT TO THE LABORATORY FOR TESTING

From each of these test plates, four (4) Standard American Welding Society* Test Coupons shall be cut, as shown in Fig. 12, and shipped to a testing laboratory designated by the Secretary for the district, to be tested for tensile strength. A log of the observed data (see Form 102) shall be filled out in triplicate and be sent, one copy to the SHOP, one copy to the LABORATORY and one copy to the COMMITTEE.

Shop Note

The plain coupons, 18 in. long by 2 in. wide, shall be removed by the shop from the test plate by sawing or by cutting with an oxy-acetylene cutting torch. The coupons shall then be machined to the

*See Bulletin No. 1 American Bureau of Welding; also A. S. T. M. Standards A7-24, A8-24, A9-24, etc., and A. S. T. M. Tentative Standard E8-25T. The essential dimensions are width of reduced section 1½ in., length 9 in., ends 2 in. wide and about 3 in. long. Fillet radius between 1 and 3 inches.

approximate dimensions, shown in Fig. 12, and any reinforcement of the weld above the base metal shall be removed by machining or grinding, so that the thickness of the coupons at the weld shall not exceed the thickness of the base metal.

Identification Marks

Before the test plate is cut into coupons, a mark identifying the particular plate shall be stamped on each of the four coupons, each side of the weld,* using letters and numerals not less than ⅜ in. high. It is obviously important to see that all samples are marked *clearly, carefully* and *accurately.* An explanation of the identifying mark, with a sample case is given below.

A	LETTER FOR SHOP DESIGNATION
B	LETTER FOR WELDERS IDENTIFICATION
H	POSITION OF THE PLATE DURING WELDING— V=VERTICAL; H=HORIZONTAL
1	NUMBER OF THE TEST PLATE
—	COUPON NUMBER

WELDER "B" FROM SHOP "A" SHALL HAVE AT LEAST 5 PLATES, MARKED ABH1, ABH2, ABH3, ABV1, ABV2. THE COUPONS TAKEN FROM THESE PLATES WOULD ALSO BE NUMBERED AS ABH21, ETC.

Required Tensile Strength

The average tensile strength of all the coupons shall not be less than 52,000 lb. per square inch and the minimum tensile strength of any one coupon shall not be less than 50,000 lb. per square inch. These values are fixed only for the purpose of qualifying welders and are not intended to furnish a basis for safe working unit stresses. The coupons shall be tested on a testing machine, which has been checked for accuracy, and the speed of the movable head of testing machine shall not exceed ⅜ in. per minute until after yield point has been reached. Ultimate tensile strength and appearance of fractured specimen shall be recorded.

*Identification marks should be so placed that they will not be defaced in grips of testing machines or cause premature failure of specimens. Position shown in Fig. 12 required.

Form 102

Inspectors' Form for Qualifying Tests Oxy-acetylene Welding Process

WELDER'S IDENTIFICATION					
TYPE OF QUALIFICATION TEST		d	e	f	g
POSITION OF SPECIMEN DURING WELDING	Flat				
	Vertical				
METHOD OF WELDING	Forward				
	Backward				
RATE OF WELDING IN FEET PER HOUR	Flat				
	Vertical				
DATES OF TESTS					
NUMBER OF COUPONS TAKEN					
WELDING WIRE	Trade Name				
	Diameter in Inches				
WELDING TORCH	Trade Name				
	Type				
	Nominal Tip Size				
GAS CHARACTERISTICS	Oxygen Average Pressure				
	Acetylene Average Pressure				
REMARKS					

NOTE: Under REMARKS shall be noted any irregularities that might prevail or develop during the tests, such as defective base metal, improper welding flame, irregular gas pressures, lapping of plates due to improper spacing, non-continuity of welding, etc.

NOTE: PLATE IDENTIFICATION FOR "g" SPECIMENS. Each coupon in each plate shall be marked at both ends as follows:

First letter is to be the Shop Designation.

Second letter is to be the Welder's Designation. These letters, assigned by the Inspector, shall be A, B, C, etc., depending upon the number of welders assigned by the shop to the work.

Third letter is to show by H or V whether the specimen has been welded in a horizontal (flat) or vertical position.

The number at the end is to identify the sequence in which the specimen was welded, the first plate bearing the number 1, the second 2, etc.

Therefore, with Welder B from Shop "A" welding the second specimen of the "g" test horizontally, the coupons cut therefrom would bear the identification ABH21 to ABH24.

Form 100

LOG OF WELDER'S EXPERIENCE

(To Be Filled in by Inspector and Approved by Employer at Date of Qualifying Test)

Welder's Identification	Years Welding Experience			General Class of Work	Kind of Welding Rod Familiar With	Remarks State here if "Shop" previously subjected welder to qualifying test or any form of Procedure Control Welding. If so, give average results, if obtainable.
	Arc		Gas			
	D.C.	A.C.				
Welder—"A"	8			Plate Steel	Bare Soft Iron	Coupon Tests Demanded Every 6 Weeks Explanation sheets can be added to further detail experience.
Welder—"B"			6	Tanks—Piping Sheet Metal Work.	Norway	Initial qualifying test only.

(Typical Entries)

Serial No.....
District "A"
Shop Approval Bill White, Supt.

Shop Smith & Co.
Inspector John Jones
Date Aug. 6th, 1927

SECTION C—WELDING SPECIFICATIONS FOR TEST SPECIMENS

(1) Quality of Steel

The grade of steel contemplated for the entire range of tests shall be Open Hearth Structural Steel for Buildings conforming to the latest A. S. T. M. Specifications A-9.

Any material containing laminations must be rejected.

(2) Preparation for Welding

In order to keep the variables in these tests to a minimum, the committee requires all joints to be prepared by non-portable machine tools,* usually found in fabricating shops. The allowable tolerance for the squareness of joint faces to be welded shall be within the limits of good shop practice. The allowable tolerance for beveled joint faces to be welded shall be within 5 deg. either way, and for shoulder dimensions, within 1/32 in. of the specified dimension. To avoid eccentricity of load during the test, careful alignment of the specimen before and during welding is necessary. This can best be accomplished by rigid clamping or by tacking the specimens, especially for the larger types.

The welding surface of all base metal shall be reasonably cleaned of foreign matter or oxide immediately before welding. The surface of metal, where welding is to be done, shall be cleaned with a wire brush in the event of the presence of rust. For test purposes in order to show strain lines care shall be taken not to remove mill scale from bars except where injurious to welding.

The surface of arc welds shall be carefully cleaned of adhering scale with a wire brush or by chipping, before super-imposing additional layers of weld metal.

(3) Position of Specimen During Welding

All specimens shall be welded with the principal or longitudinal axis horizontal and with the plate faces of the "C" bars lying flat on the welding table or support unless otherwise specified.

Where welding is to be done on both sides of a specimen, the specimen shall be turned over upon the completion of a weld on one side, so that the face of the "C" bars lies flat as above, with the exception of the rivet weld specimens 6600 and 6700 and the

*Machine tools such as a power shear, saw, miller, shaper or planer.

band weld specimens 6800 and 6900, which may be placed with the faces of the "C" bars vertical.

No specimens are to be inclined to facilitate welding, but shall be flat at all times during the welding operation.

(4) Welding Rods or Filler Material

The welding rods or filler material to be used in welding the Test Specimens by the gas process shall be of a grade that will develop a minimum of 56,000 lb. per square inch in tension in a butt weld joining two (2) mild-steel plates.

The filler material or electrodes to be used in welding the Test Specimens by the electric process shall be a bare wire conforming to the American Welding Society specifications designated as Class E1A or E1B.

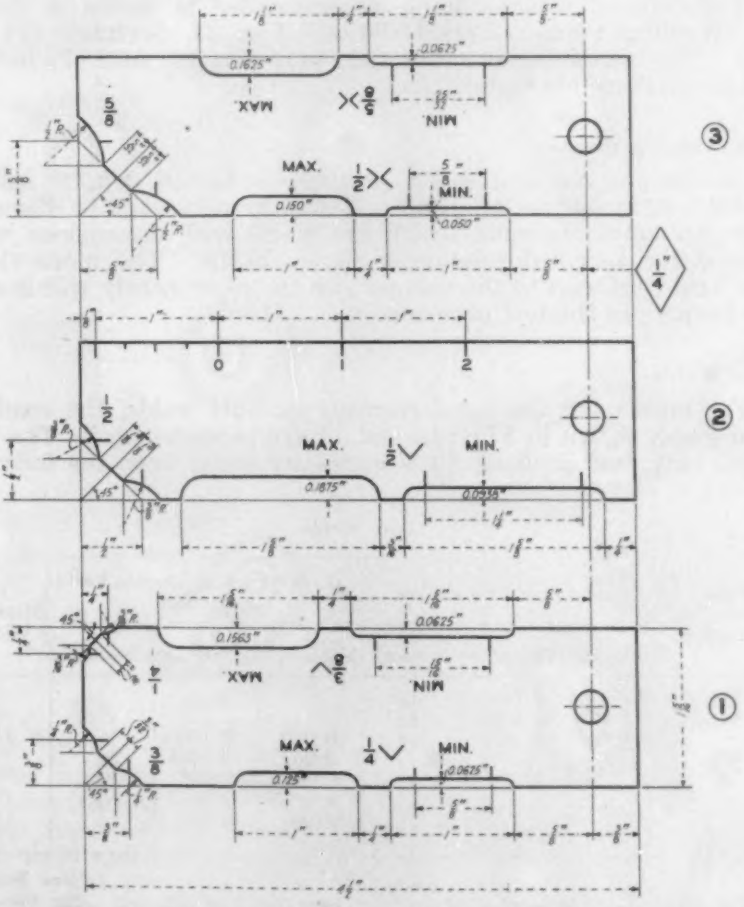


FIG. 13—GAGES FOR MEASURING BUTT AND FILLET WELDS

(5) Preparatory Tacking

All specimens may be clamped or tacked† before welding by the respective processes employed for the welding of the specimens. Location of tacks is suggested on the Specimen Data Sheets by ●⟶ notation. As tacks are encountered during the final welding operation (oxy-acetylene welding only), they shall be thoroughly rewelded.

(6) Welding Arc

The current used shall at all times be within 5 per cent plus or minus of that specified for each type of specimen. The voltage across the arc shall not exceed 20 volts.

(7) Welding Gas Flame

The type of welding flame recommended is shown in Section D "Welding Flame Characteristics," Fig. 24, Sketches (1) and (2). The remaining sketches (3), (4), (5), (6) and (7) indicate incorrect flame characteristics.

(8) Gaging Welds

As the purpose of the test program is to test definite sizes of welds within certain tolerances, it will be necessary to disqualify any test specimen upon which are welds with dimensions which exceed the specified tolerances shown below. The more closely the weld conforms to the normal size the more nearly will it serve its purpose in the test program.

Butt Welds

For measuring the reinforcement on butt welds, the combination gages shown in Figs. 13 and 14 are recommended. The indicated butt weld profiles of the gages are based upon the following table:

Butt Welds

Plate Thickness in Inches	Reinforcement Single Vee			Reinforcement Double Vee Each Side			Minimum Width*
	Minimum	Maximum	Normal	Minimum	Maximum	Normal	
1/4	0.0625	0.125	3/32	.....	.....	.....	5/8
3/8	0.0625	0.1563	3/32	.....	.....	.....	15/16
1/2	0.0938	0.1875	1/8	0.050	0.150	3/32	1 1/4-5/8
5/8	.....	.....	.....	0.0625	0.1625	3/32	15/32
3/4	.....	.....	.....	0.075	0.175	1/8	15/16
7/8	.....	.....	.....	0.0875	0.1875	5/32	1 3/32
1	.....	.....	.....	0.100	0.200	5/32	1 1/4

*Gas Welding.

†A tack is an intermittent weld used for assembly purposes only. For these test specimens tacks should be about ½ in. in diameter. See Fig. 31.

A weld shall at no point fall below the minimum crown height shown. The average profile of the weld shall be between the minimum and maximum limits as shown on the gage.

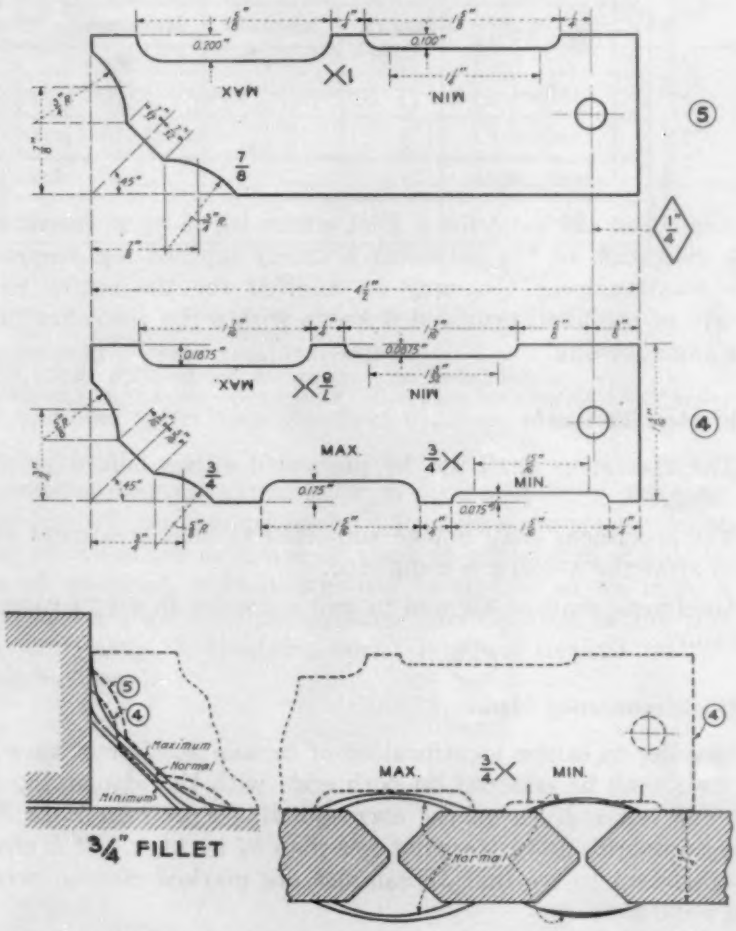


FIG. 14—GAGES FOR MEASURING BUTT AND FILLET WELDS AND A SKETCH ILLUSTRATING METHOD OF APPLICATION OF THESE GAGES

Fillet Welds

The combination gages shown in Figs. 13 and 14 are also recommended for gaging fillet welds. The indicated fillet profiles of the gages are based upon the following table.

A weld shall at no point fall below the minimum triangle indicated. The average profile shall be between the limits indicated on the gage corresponding to the designed fillet size and the limits

Fillet Welds

Designed Size	Leg		Throat		
	Minimum	Maximum	Minimum	Maximum	Normal
1/4	1/4	3/8	0.177	0.265	0.221
3/8	3/8	1/2	0.265	0.354	0.309
1/2	1/2	5/8	0.354	0.442	0.398
5/8	5/8	3/4	0.442	0.530	0.486
3/4	3/4	7/8	0.530	0.619	0.574

indicated on the gage for a fillet whose leg is 1/8 in. greater. At the discretion of the inspector a thinly tapered leg overrunning the maximum leg size may be allowed for the entire running length of the fillet, provided it keeps within the clearance limit of the gage opening.

(9) Heat Treatment

The specimens shall not be preheated either before or during welding.

The specimens shall not be subjected to heat treatment of any kind after the welding is completed.

Specimens shall be allowed to cool normally in air to room temperature.

(10) Identification Marks

In order to insure identification of broken specimens, each piece of steel shall be stamped on both ends with the identifying number and letter given on the corresponding Specimen Data Sheet; using numerals and letters not less than 3/8 in. high. It is obviously important to see that all samples are marked *clearly, carefully* and *accurately*.

For explanation of Marking Systems see Item 12.

(11) Packing of Specimens for Shipment to Laboratory

It is important that the welded specimens be delivered to the laboratory in the same condition as when the welding was completed. To insure this, the committee recommends that the specimens be boxed, crated, or otherwise protected against damage during shipment to the laboratory. The exact manner will be left to the SHOP.

(12) System for Marking Specimens

EXAMPLE			
S	KIND OF STEEL (USE ONLY IF SPECIAL)	CAPITAL LETTER	DESIGN
10	TYPE OF SPECIMEN (SEE SPECIMEN DATA SHEET)	2 FIGURES	DESIGN
5	THICKNESS OF MATERIAL (IN EIGHTHS)	1 FIGURE	DESIGN
3	WELD (IN EIGHTHS)	1 FIGURE	DESIGN
A	SHOP	CAPITAL LETTER	PRODUCTION
2	SPECIMEN SERIAL	1 FIGURE	PRODUCTION

FIG. 16

Silicon steel to carry initial letter "S."
Copper steel to carry initial letter "C."
High carbon steel to carry initial letter "H."
Steel to A.S.T.M. Specification A-9 to carry no initial letter.
For the above specification, see page 48 "Steel Construction" A.I.S.C. under "Standard Specifications for Structural Steel Buildings," Serial Designation A-9-21.

The preceding diagram explains the method adopted by the committee for identifying the specimens. It gives a simple means of indicating such factors as grade of steel, if other than standard, thickness of material, weld dimensions in eighths of an inch, a capital letter for each fabricating shop participating in the test program, and lastly, a specimen serial number as used by the Committee on Tests.

AMERICAN BUREAU OF WELDING

STRUCTURAL STEEL WELDING COMMITTEE

Specifications for Test Specimens—Their Preparation and Testing

SECTION D—INSPECTION AND SUPERVISION

GENERAL INSTRUCTIONS

It is explained in Section A that the duty of the inspectors of this work will be primarily to conduct, first the Preliminary or Qualification Test of Welders, and second, to inspect the material for and witness the welding of, the Test Specimens.

Of most importance in this work are the Qualifying Tests. Intelligent application of these tests will do more to assist the committee and the SHOPS toward accomplishing their joint objective than any other part of the program.

The work of Qualifying Welders is described in detail in Section "B," for both Metal Arc and Gas Welding. Supplementary instructions and recommended practices are set forth in part (1) and (2) of this section to guide the inspectors and SHOPS in this work.

The inspector's duties in connection with the welding of the Test Specimens (described in Sections "B" and "C") shall be that of correctly recording the manner in which these specimens have been prepared for welding and have been welded. Only qualified welders shall be allowed to weld Test Specimens. The inspector shall not give instructions to welders but shall inspect the material as prepared by the SHOPS for welding, and gage same for the tolerances specified in the body of the Procedure.

The information in detail, required by the committee in connection with these specimens, is tabulated on Standard Form Nos. 100, 101 and 102. The space for remarks has been provided for the purpose of recording any deviations from the committee's specifications.

One entry on Form 102, "Method of Welding," refers to Gas Welding. It provides for recording the direction in which the weld progresses with respect to progression of the welding flame. This is illustrated in this section "Method of Welding," Fig. 30. This item has been included for the purpose of determining if any advantage in penetration and weld quality is gained by either method, therefore this item should be noted and properly checked on the form.

The welding technical factors involved in this work, such as (1) selection of materials, (2) preparation of plates and specimens for welding, (3) methods of welding, (4) weld quality, (5) weld strength, etc., are specified, where involved, for each detail welding application. The inspector must acquaint himself with these factors in order that he may properly appraise them on the several forms he is required to fill out.

The inspector's attention is called to the item of properly marking the coupons and specimens as described in the body of the specifications. If this is overlooked, the specimens not bearing the specified identification will be rejected. For explanation of the marking system see Fig. 16.

Part 1

Inspection Data for Direct Current Metal Arc Welding

The skilled inspector can readily determine when the operator is doing good work. Among the several factors which determine the physical characteristics of metal arc welds are: current, arc

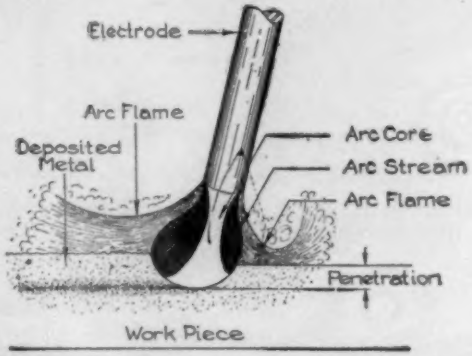


FIG. 17—DIAGRAM OF THE WELDING ARC

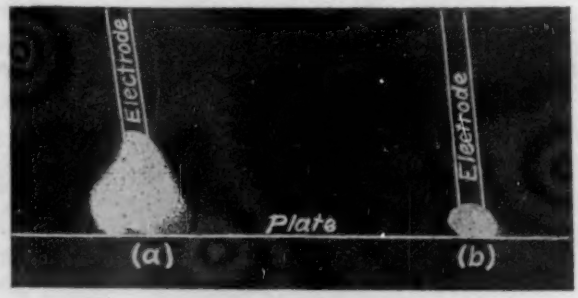


FIG. 18—LONG AND SHORT WELDING ARC, LONG ARC STREAM CAUSES EXCESSIVE OXIDATION

voltage, depth of penetration, overlap, appearance of crater, arc and deposited metal.

Current

The current being used by the operator is readily determined by an ammeter. The current will, of course, vary with the thickness of the material, size of the electrode, type of joint and the method of preparation. For example, a welding current of 150 amp. will produce satisfactory penetration on welding the apex of scarfed ½-in. plates. If the joint is backed by a steel plate, increasing

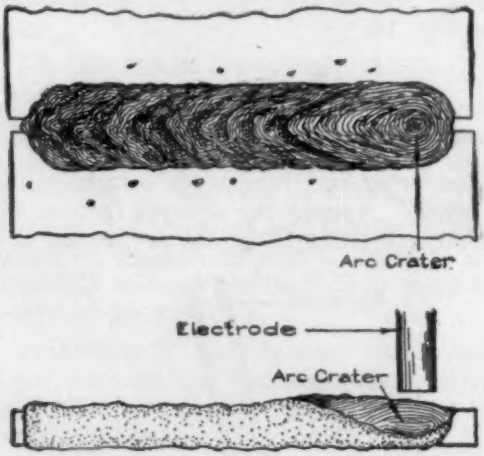


FIG. 19—LONGITUDINAL SECTION OF DEPOSITED METAL SHOWING PENETRATION AND ARC CRATER

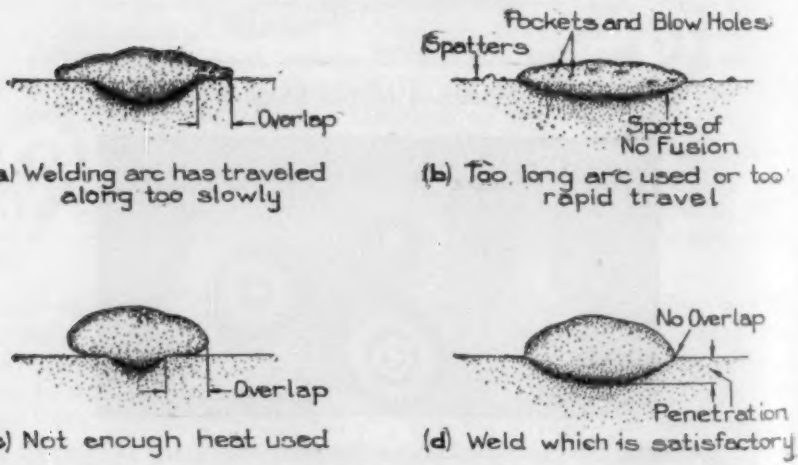


FIG. 20—CROSS SECTIONS OF BEADS DEPOSITED UNDER DIFFERENT CONDITIONS

both its thermal capacity and conductivity, a higher current, in the neighborhood of 175 amp. to 200 amp. should be used. If the plates are lapped it would be better to use a 3/16-in. electrode using 225 amp. The size of electrode and amount of current used are specified in detail in each case. The inspector should see to it that these conditions are followed as closely as possible.

Arc Voltage

The arc voltage determines the length of the arc with a given current. The exact value can readily be determined by a volt-

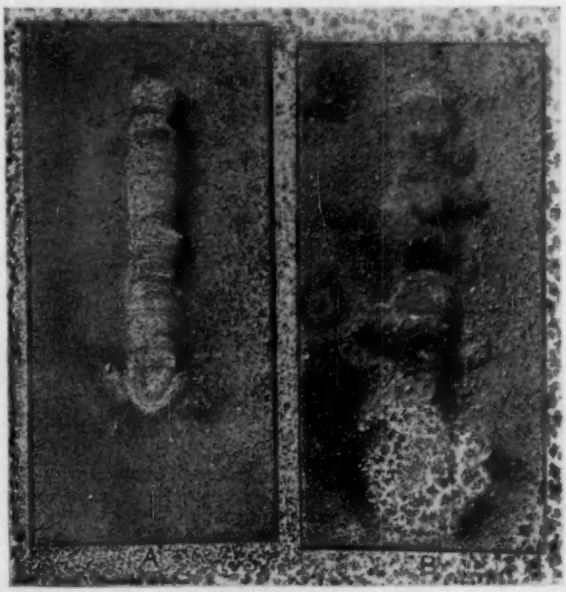


FIG. 21—DEPOSITS OBTAINED WITH SHORT ARC AND LONG ARC. NOTE THAT SURFACES OF DEPOSIT AND PLATE IN (B) ARE HEAVILY COATED WITH IRON OXIDE, WHILE THOSE IN (A) ARE COMPARATIVELY CLEAN

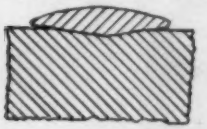
meter. In manual welding with bare electrodes up to 3/16-in. in diameter, it should seldom exceed 20 volts for good work. A long arc results in improper fusion, lack of proper penetration and a deposit of inferior oxidized metal. The metal is merely melted and poured on the work and the quality of the weld is inferior. Through the maintenance of a short arc, not exceeding ⅛ in., the resulting oxidation is a minimum.

A long arc is easily recognized, not only by the higher voltage, but also by the "flame" effect. A short arc throws a steady shower of small sparks, whereas each of the explosions caused by a long arc scatters a considerable number of larger globules of metal.

The use of a short arc with bare electrodes results in the familiar crackling, snapping effect that is fairly steady in intensity. A small crater is formed around the arc showing the depth of penetration. If the arc is punctuated by explosions occurring at intervals of one-half second or more, the arc is too long.

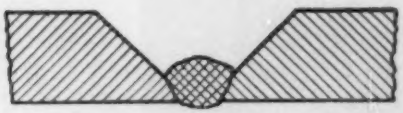
Depth of Penetration

The depth of penetration is dependent upon the length of the arc, the amount of current being used and the rate of travel. This is readily discernible by a skilled inspector during the welding process. In a measure, it may also be determined by the appearance of the work and the depth of the arc crater. The depth of the



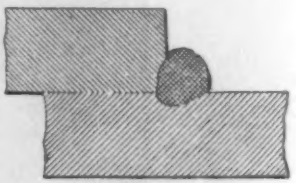
a

b



a

FIG. 22—(a) EXCESSIVE OVERLAP SECURED WITH AN ELECTRODE (DRILL ROD) HAVING A LOWER MELTING TEMPERATURE THAN THE BASE METAL (MILD STEEL). (b) "CUTTING" SECURED THROUGH USE OF HIGH ARC CURRENT



b

FIG. 23—OVERLAP AND PENETRATION STUDIES. (a) SECTION INDICATES PROPER SELECTION OF WELDING CURRENT AND ELECTRODE DIAMETER TO SECURE FUSION. (b) ADEQUATE FUSION OBTAINED BY INCREASING CURRENT TO COMPENSATE FOR INCREASED RATE OF HEAT FLOW

arc crater should not be less than 1/16 in. This is clearly illustrated in the accompanying illustrations. When welding base metal of unequal thicknesses uniform penetration is secured by playing the arc on the thicker material for a proportionately longer time.

Overlap

The appearance of the edges of a bead deposited by arc welding is a good criterion of the quality of the work. In good work there is an absence of what is termed a "re-entrant angle." There is an intimate contact between the plate and deposit being secured, the junction between the two metals often forming a concave surface. It is impossible to penetrate under the bead with a knife. On the other hand, in poor work there is an appreciable overlap. The edge of the deposit does not form an intimate contact with the plate and the "re-entrant angle" between the deposit and the plate is pronounced. These conditions are indicated in the several illustrations. Overlap is usually caused by a long arc, too low a current or too great a speed of travel.

Appearance of Deposited Metal

The appearance of the weld after the work is finished furnishes some indication of its quality. Even, smooth welds generally indicate skilled workmanship, and, as pointed out above, the form of rise of the weld above the surrounding plate metal indicates whether proper fusion has been obtained. The surface of a good deposited weld is clean and smooth. The surface of an improper deposited weld is irregular and covered with a heavy coating of oxide. In poor welding the surface will be at times pitted.

PART 2

Inspection Data for Gas Welding

Qualifying tests as set out in Section "B," Part 2, provide four (4) separate tests. The first two (d) and (e) may be eliminated in cases where the welding skill is obviously of high degree and where opportunity is afforded the inspector to observe the welder's skill on SHOP production welding. Tests (f) and (g), however, must be applied to each welder.

It is the inspector's duty to properly appraise the welder's ability to weld in accordance with the practices recommended in this procedure.

The following is submitted in further explanation of these practices, the principal factors of which from a manual standpoint, have been taken up.

(a) A clean welding tip.

(b) An arrangement of hose and other welding facilities that provides for comfort of welder during welding operation.

(c) A soft and regular inner cone similar to the type shown in Sketches 1 and 2 of Fig. 24, "Welding Flame Characteristics." Gas pressures will vary with different types of torches and with different lengths of hose, therefore the inspector is advised to observe the welding flame conditions rather than the pressures of the two gases. Good weld metal will not be produced if the welding flame is not properly maintained. It is important that a welder have good tools to work with and the welding flame is his main tool.

(d) Thorough penetration or the fusion of weld and base metal down to the root of the weld or to the bottom of the "V" is essential. Figs. 25 and 26 illustrate this point.

When welding base metals of unequal thicknesses, uniform penetration is secured by playing the flame on the thicker material for a proportionately longer time.

For base metal 7/16 in. and thicker, penetration is easily attained if the welder gives attention to the sequence of deposition. A shallow or light deposit of weld metal should be made in the throat of the weld as shown in Fig. 27 at "A," which should continually precede the final deposit (one or more layers). It need not "run ahead" of the final deposit over ¾ in. to 1 in., depending upon the thickness of the base metal and the habits of the welder.

For metal up to 7/16 in. thick, the weld, as a rule, is made with one deposit or with one operation, and penetration under such a condition is best attained when the welder is in a position before the work so that both sides of the "V" or both faces of the joint are visible to him. A skilled welder will maintain a definite puddle of weld metal under his torch continually, the consistency of which resembles in a miniature way, the molten metal in a foundry ladle.

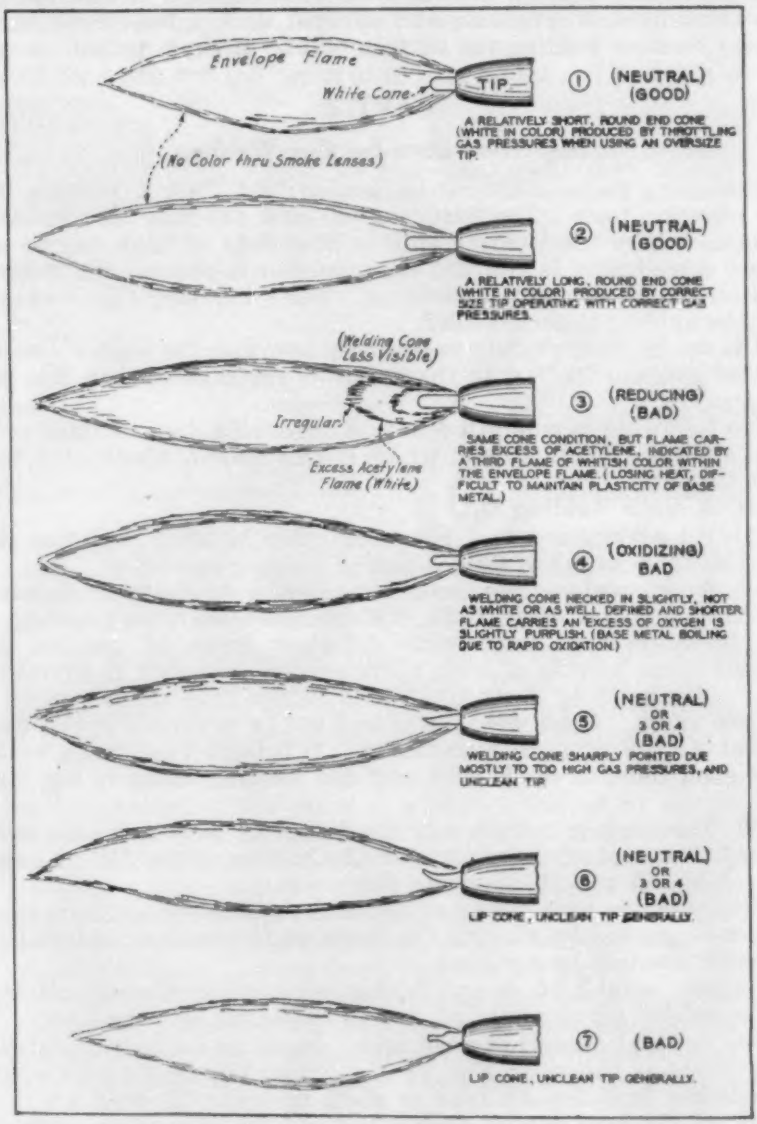

Envelope Flame
White Cone
TIP
① (NEUTRAL) (GOOD)
A RELATIVELY SHORT, ROUND END CONE (WHITE IN COLOR) PRODUCED BY THROTTLING GAS PRESSURES WHEN USING AN OVERSIZE TIP.
(No Color thru Smoke Lenses)
② (NEUTRAL) (GOOD)
A RELATIVELY LONG, ROUND END CONE (WHITE IN COLOR) PRODUCED BY CORRECT SIZE TIP OPERATING WITH CORRECT GAS PRESSURES.
(Welding Cone Less Visible)
Irregular
③ (REDUCING) (BAD)
SAME CONE CONDITION, BUT FLAME CARRIES EXCESS OF ACETYLENE, INDICATED BY A THIRD FLAME OF WHITISH COLOR WITHIN THE ENVELOPE FLAME. (LOSING HEAT, DIFFICULT TO MAINTAIN PLASTICITY OF BASE METAL.)
Excess Acetylene Flame (White)
④ (OXIDIZING) BAD
WELDING CONE NECKED IN SLIGHTLY, NOT AS WHITE OR AS WELL DEFINED AND SHORTER. FLAME CARRIES AN EXCESS OF OXYGEN IS SLIGHTLY PURPLISH. (BASE METAL BOILING DUE TO RAPID OXIDATION.)
⑤ (NEUTRAL) OR 3 OR 4 (BAD)
WELDING CONE SHARPLY POINTED DUE MOSTLY TO TOO HIGH GAS PRESSURES, AND UNCLEAN TIP.
⑥ (NEUTRAL) OR 3 OR 4 (BAD)
LIP CONE, UNCLEAN TIP GENERALLY.
⑦ (BAD)
LIP CONE, UNCLEAN TIP GENERALLY.

FIG. 24—FLAME CHARACTERISTICS

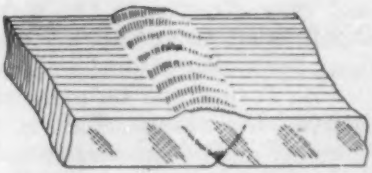


FIG. 25—WELD NOT PENETRATED

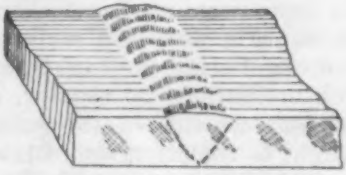


FIG. 26—ADHESION

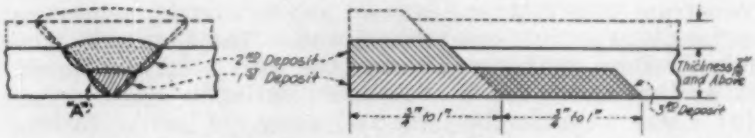


FIG. 27—METHOD OF DEPOSITING METAL

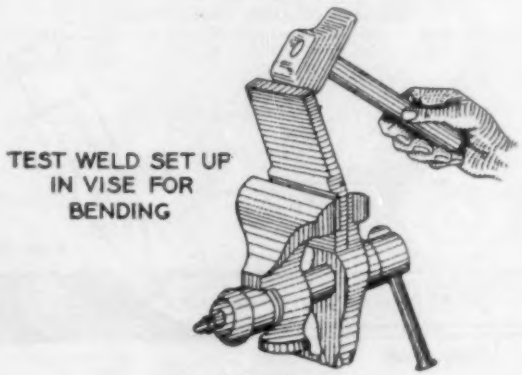


FIG. 28

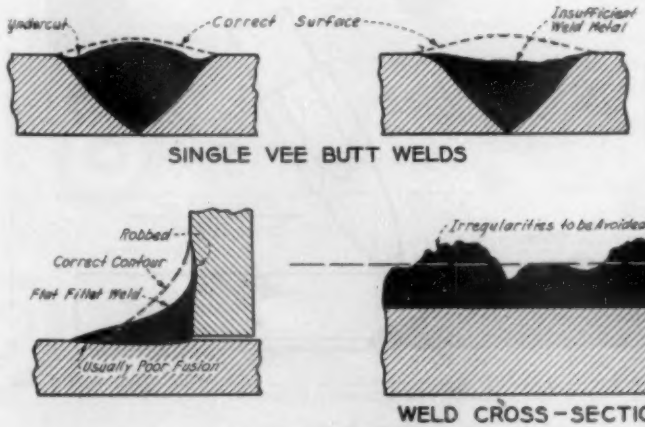


FIG. 29—CONTOUR OF WELDS

The inner welding flame should not play directly on the welding rod, but around it in a semi-circular fashion, the rod being melted by the radiating heat of the flame. It is also essential that the torch oscillations be regular, otherwise fusion will be more thorough on one side of the joint than on the other. This is best brought to the attention of the welder by one of the vise tests and should be illustrated when the inspector finds welders with this fault.

The fillet weld test is primarily to ascertain the welder's ability to penetrate with this type of joint and to control metal deposited in a flat plane against one vertical wall. The fillet weld should be evenly disposed on the two faces of the base metal and should conform to the dimensions of these specifications.

(e) Clean metal in the joint and along the line of fusion. Inspector should observe if the welder eliminates impurities in the metal exposed by the welding operation. These impurities, mostly

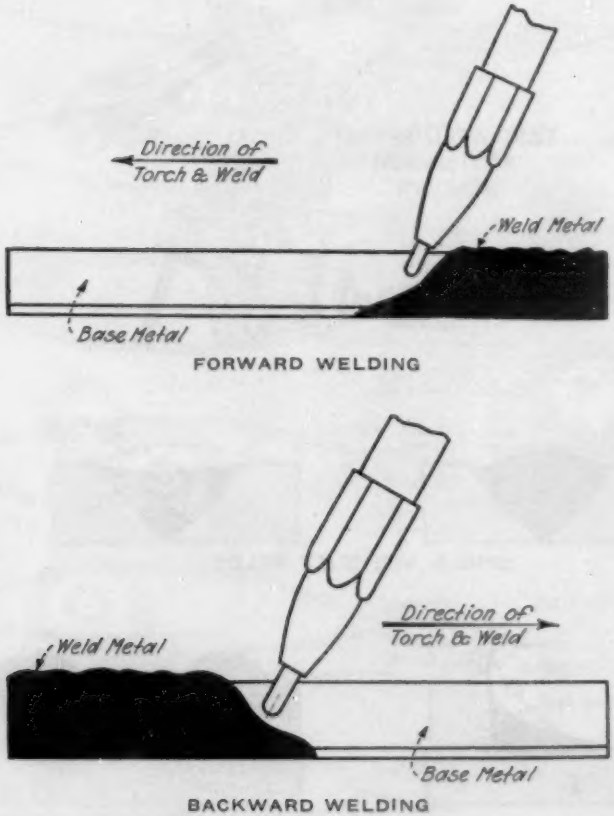


FIG. 30—METHODS OF WELDING

oxides, appear as small white "specks" or "plates" in the molten metal and can be "floated" to the surface by fusing below their lodgment.

(f) Workmanlike weld finish which also embraces weld reinforcement and width. The contour of the weld should be quite regular and show evidence of controlled welding conditions. Inspector should observe whether the base metal on either side of the weld has been "robbed" similar to the illustration, Fig. 29, or the surface of the deposited metal "Ridged" at intervals.

These irregularities can only be overcome by proper instruction and practice. Their existence, when proper materials have been selected, generally indicates one of two things: inexperience on the part of the welder or undue haste in welding.

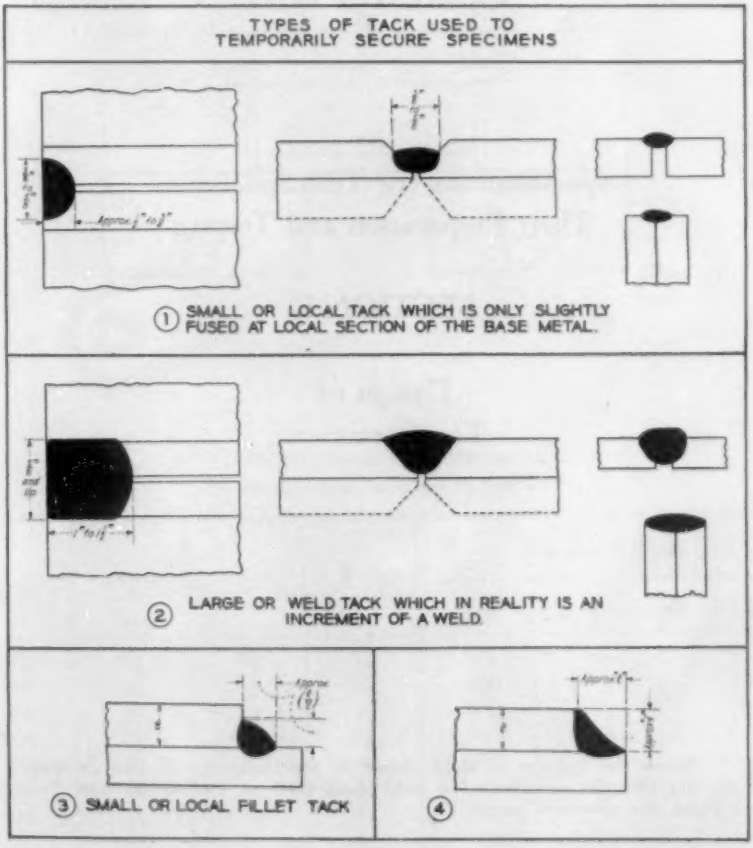

TYPES OF TACK USED TO TEMPORARILY SECURE SPECIMENS
① SMALL OR LOCAL TACK WHICH IS ONLY SLIGHTLY FUSED AT LOCAL SECTION OF THE BASE METAL.
② LARGE OR WELD TACK WHICH IN REALITY IS AN INCREMENT OF A WELD.
③ SMALL OR LOCAL FILLET TACK
④

FIG. 31

AMERICAN BUREAU OF WELDING

STRUCTURAL STEEL WELDING COMMITTEE

Specifications for Test Specimens
Their Preparation and Testing

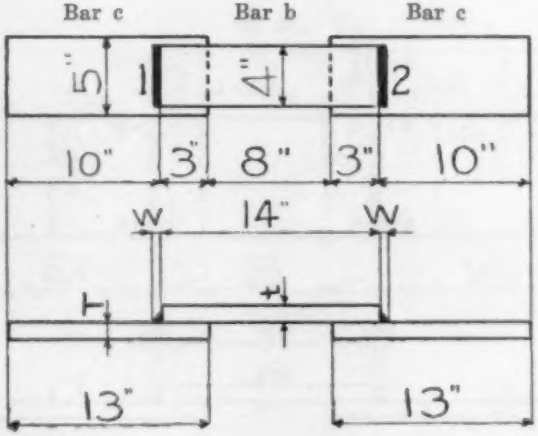
SECTION E

Design of
Test Specimens

Note: the lengths of weld shown in the diagrams of this Section are net effective lengths. No weld shall start or end more than ¼" beyond the effective length.

Specimens of 1000 Series

Single Strap in Normal Shear One End—Continuous Fillet Welds.



SPECIMENS OF 1000 SERIES

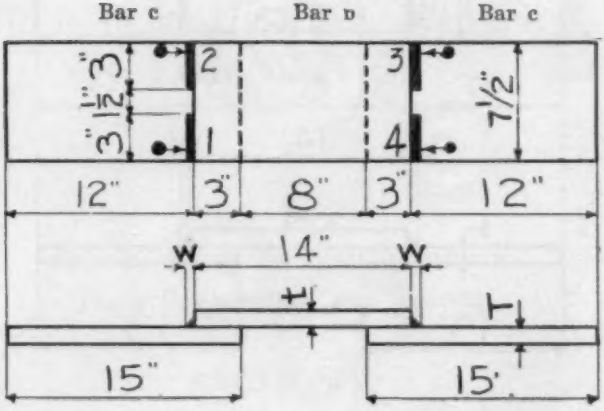
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld W	For Arc Welding		
				Amp.	Size of Wire	No. of Layers
1022	¼	⅜	¼	160	5/32	1
1033	⅜	⅜	⅜	200	3/16	1
1044	½	½	½	200	3/16	2
1055	⅝	½	⅝	200	3/16	2
1066	¾	¾	¾	200	3/16	3
1043	½	½	⅜	200	3/16	1
1053	⅝	½	⅜	200	3/16	1
1063	¾	¾	⅜	225	3/16	1

General Instructions: Order of welding (arc and gas) No. 1, 2, 3, 4. Clamp or tack for arc welding, clamp for gas welding.

Specimens of 1100 Series

Single Strap in Normal Shear One End—Intermittent Fillet Welds.



SPECIMENS OF 1100 SERIES

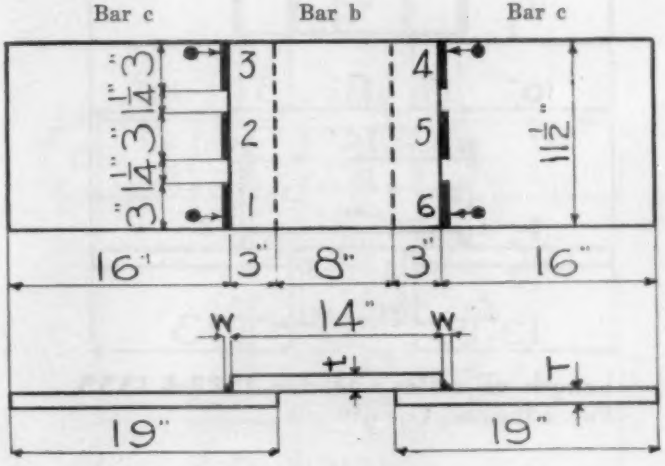
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld W	For Arc Welding		
				Amp.	Size of Wire	No. of Layers
1133	3/8	1/2	3/8	200	3/16	1
1143	1/2	3/4	3/8	200	3/16	1
1153	5/8	3/4	3/8	200	3/16	1
1163	3/4	1	3/8	225	3/16	1

General Instructions: Order of welding No. 1 and then No. 2 for arc and gas or tack at points marked ●→ for arc welding, clamp for gas welding.

Specimens of 1200 Series

Single Strap in Normal Shear One End—Intermittent Fillet Welds.



SPECIMENS OF 1200 SERIES

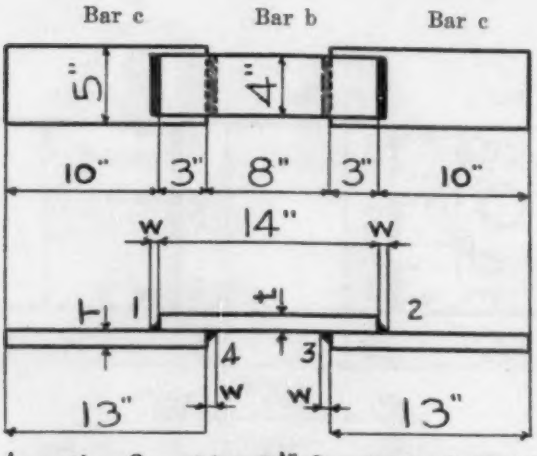
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld W	For Arc Welding		
				Amp.	Size of Wire	No. of Layers
1233	3/8	1/2	3/8	200	5/16	1
1243	1/2	3/4	3/8	200	5/16	1
1253	5/8	3/4	3/8	200	5/16	1
1263	3/4	1	3/8	225	5/16	1

General Instructions: Order of welding (arc and gas) 1, 2, 3—4, 5, 6. Tacking if employed (arc or gas) at points marked ●→

Specimens of 1300 Series

Single Strap in Normal Shear Both Ends—Continuous Fillet Welds.



Length of welds = 3½" for 1322 & 1333.
For others Length = 4".

SPECIMENS OF 1300 SERIES

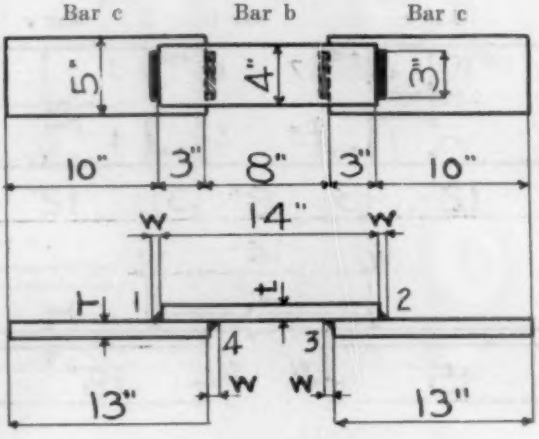
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld W	For Arc Welding		
				Amp.	Size of Wire	No. of Layers
1322	¼	⅜	¼	160	5/32	1
1333	⅜	½	⅜	200	3/16	1
1344	½	¾	½	200	3/16	2
1355	⅝	¾	⅝	200	3/16	2
1366	¾	1	¾	200	3/16	3
1343	½	¾	⅜	200	3/16	1
1353	⅝	¾	⅜	200	3/16	1
1363	¾	¾	⅜	225	3/16	1

General Instructions: Order of welding (arc and gas) No. 1, 2—3, 4. Clamp or tack for arc welding, clamp for gas welding.

Specimens of 1400 Series

Single Strap in Normal Shear Both Ends—Short Continuous Fillet Welds.



SPECIMENS OF 1400 SERIES

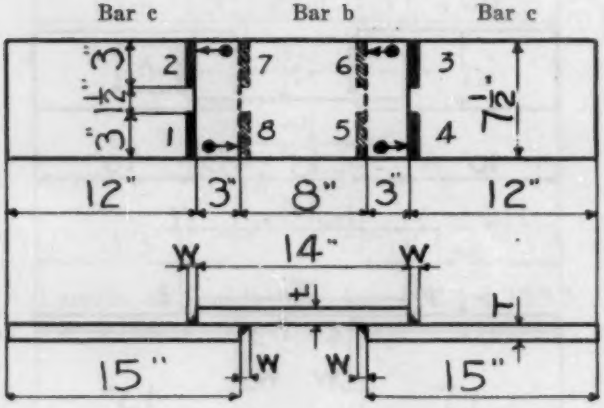
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld W	For Arc Welding		
				Amp.	Size of Wire	No. of Layers
1422	¼	⅜	¼	160	5/32	1
1433	⅜	½	⅜	200	3/16	1
1444	½	¾	½	200	3/16	2

General Instructions: Order of welding (arc and gas) No. 1, 2—3, 4. Clamp or tack for arc welding, clamp for gas welding.

Specimens of 1500 Series

Single Strap in Normal Shear Both Ends—Intermittent Fillet Welds.



SPECIMENS OF 1500 SERIES

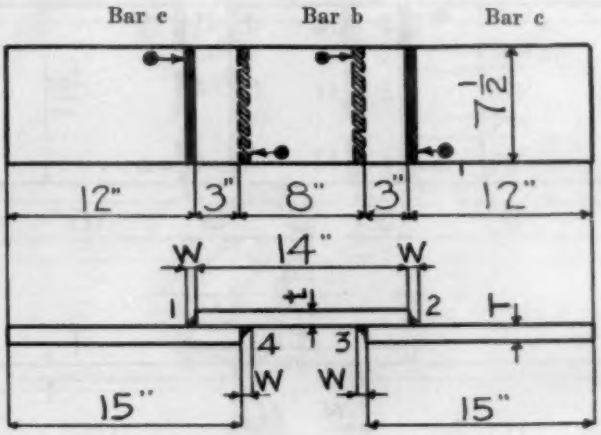
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld W	For Arc Welding		
				Amp.	Size of Wire	No. of Layers
1533	⅜	½	⅜	200	5/16	1
1543	½	¾	⅜	200	5/16	1
1553	⅝	¾	⅜	200	5/16	1
1563	¾	1	⅜	225	5/16	1

General Instructions: Order of welding (arc and gas) No. 1, 2, 3, 4—5, 6, 7, 8. Clamp or tack for arc welding, clamp for gas welding. Tacking if used at points marked ●⟶

Specimens of 1600 Series

Single Strap in Normal Shear Both Ends—Continuous Fillet Welds.



SPECIMENS OF 1600 SERIES

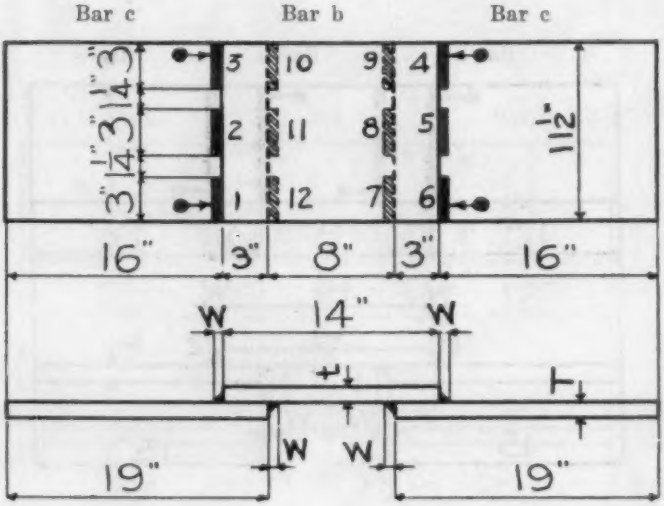
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld W	For Arc Welding		
				Amp.	Size of Wire	No. of Layers
1633	3/8	1/2	3/8	200	5/16	1
1643	1/2	3/4	3/8	200	5/16	1
1653	5/8	3/4	3/8	200	5/16	1
1663	3/4	1	3/8	225	5/16	1

General Instructions: Order of welding (arc and gas) No. 1, 2—3, 4. Clamp or tack for arc welding, clamp for gas welding. Tacking if used at points marked ●⟶

Specimens of 1700 Series

Single Strap in Normal Shear Both Ends—Intermittent Fillet Welds.



SPECIMENS OF 1700 SERIES

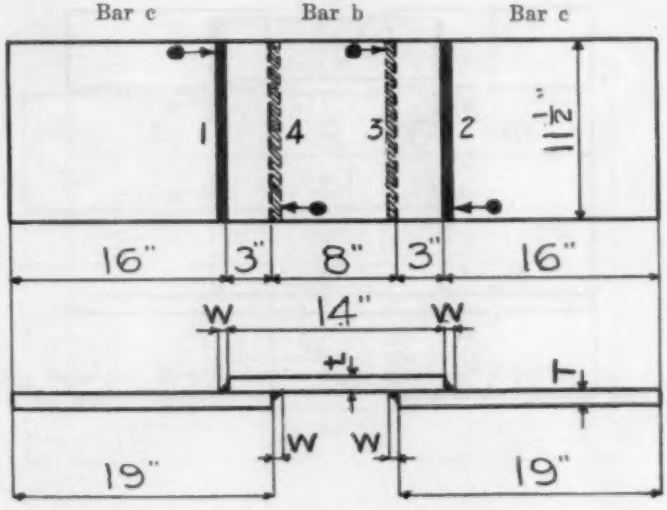
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld W	For Arc Welding		
				Amp.	Size of Wire	No. of Layers
1733	3/8	1/2	3/8	200	5/32	1
1743	1/2	3/4	3/8	200	5/32	1
1753	5/8	3/4	3/8	200	5/32	1
1763	3/4	1	3/8	225	5/32	1

General Instructions: Order of welding (arc and gas) No. 1, 2, 3—4, 5, 6—7, 8, 9—10, 11, 12. Tack for arc and gas welding at points marked ●⟶

Specimens of 1800 Series

Single Strap in Normal Shear Both Ends—Continuous Fillet Welds.



SPECIMENS OF 1800 SERIES

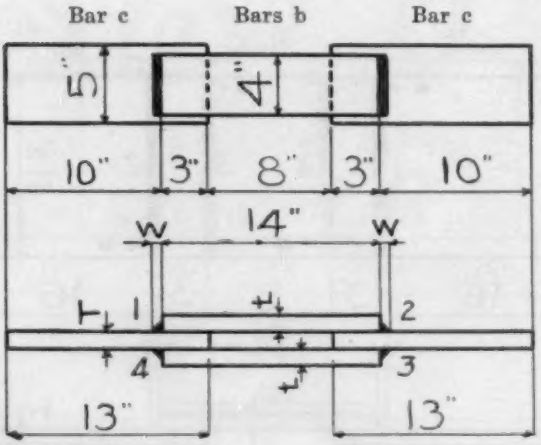
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld W	For Arc Welding		
				Amp.	Size of Wire	No. of Layers
1833	3/8	1/2	3/8	200	5/16	1
1843	1/2	3/4	3/8	200	5/16	1
1853	5/8	3/4	3/8	225	5/16	1
1863	3/4	1	3/8	225	5/16	1

General Instructions: Order for welding (arc and gas) No. 1, 2—3, 4. Tack for arc and gas welding at points marked ●→

Specimens of 1900 Series

Double Strap in Normal Shear One End—Continuous Fillet Welds.



SPECIMENS OF 1900 SERIES

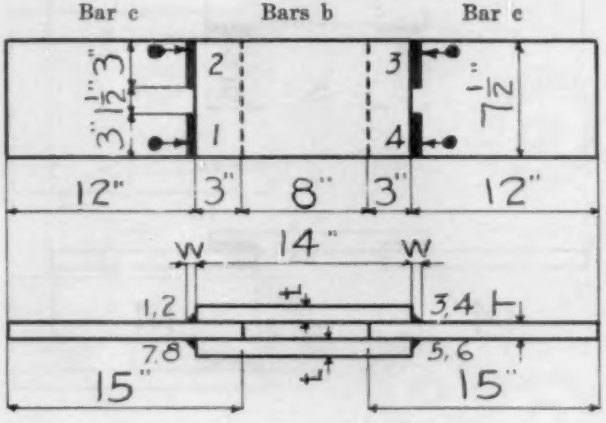
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld W	For Arc Welding		
				Amp.	Size of Wire	No. of Layers
1922	¼	½	¼	160	5/32	1
1933	3/8	¾	3/8	200	3/16	1
1944	½	1	½	200	3/16	2
1955	5/8	1	5/8	200	3/16	2
1966	¾	1	¾	200	3/16	3
1943	½	¾	3/8	200	3/16	1
1953	5/8	¾	3/8	225	3/16	1
1963	¾	¾	3/8	225	3/16	1

General Instructions: Order of welding (arc and gas) No. 1, 2—3, 4. Tack or clamp for arc welding. Clamp for gas welding.

Specimens of 2000 Series

Double Strap in Normal Shear One End—Intermittent Fillet Welds.



SPECIMENS OF 2000 SERIES

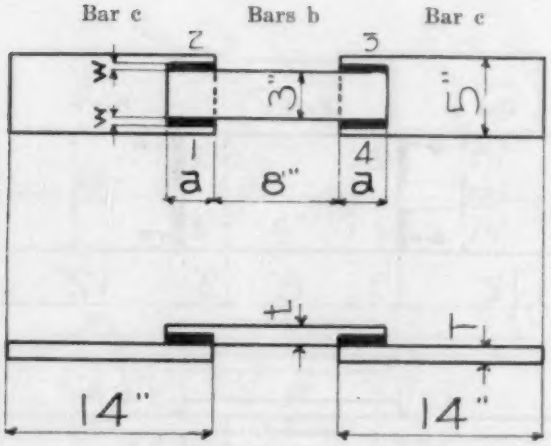
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld W	For Arc Welding		
				Amp.	Size of Wire	No. of Layers
2033	3/8	3/4	3/16	200	3/16	1
2043	1/2	1	3/8	200	3/16	1
2053	5/8	1 1/2	3/8	225	3/16	1
2063	3/4	1 1/2	3/8	225	5/16	1

General Instructions: Order of welding (arc and gas) No. 1, 2, 3, 4—5, 6, 7, 8. Tack or clamp for arc welding, clamp for gas welding. Tacking if used at points marked ●⟶ both sides.

Specimens of 2100 Series

Single Strap with Fillets in Parallel Shear.



SPECIMENS OF 2100 SERIES

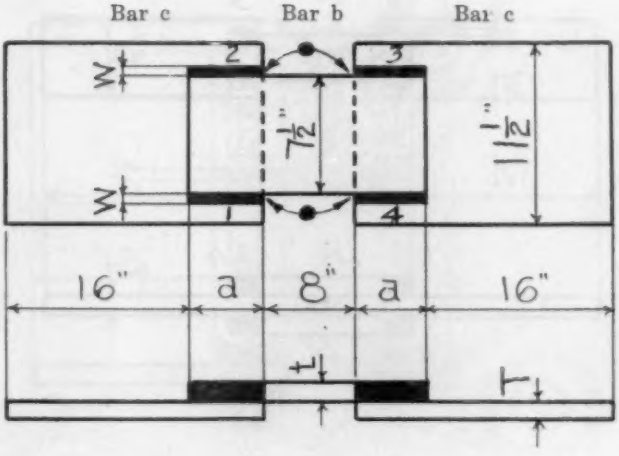
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld a	Weld W	For Arc Welding Amp.	For Arc Welding Size of Wire	For Arc Welding No. of Layers
2122	1/4	3/8	2	1/4	160	5/32	1
2133	3/8	3/8	2	3/8	200	3/16	1
2144	1/2	1/2	2	1/2	200	3/16	2
2155	5/8	3/4	2	5/8	200	3/16	2
2166	3/4	3/4	2	3/4	225	3/16	3
2143	1/2	1/2	3	3/8	200	3/16	1
2153	5/8	3/4	4	3/8	225	3/16	1
2163	3/4	3/4	4	3/8	225	3/16	1

General Instructions: Order of welding No. 1, 2, 10—3, 4, 11—7, 8, 9—5, 6, 12. Clamp or tack for acr welding. Clamp for gas welding.

Specimens of 2200 Series

Single Strap with Fillets in Parallel Shear.



SPECIMENS OF 2200 SERIES

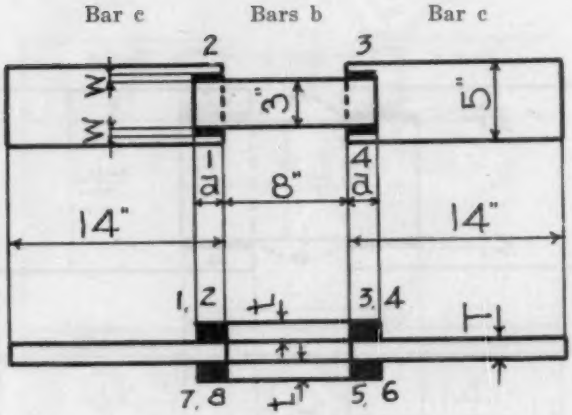
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld a	Weld W	For Arc Welding Amp.	For Arc Welding Size of Wire	For Arc Welding No. of Layers
2233	⅜	⅜	6	⅜	200	5/16	1
2243	½	½	8	⅜	200	5/16	1
2253	⅝	¾	10	⅜	200	5/16	1
2263	¾	¾	12	⅜	225	5/16	1

General Instructions: Order of welding (arc and gas) No. 1, 2—3, 4. Tack or clamp. Tacking if used at points marked ● →

Specimens of 2300 Series

Double Strap with Fillets in Parallel Shear.



SPECIMENS OF 2300 SERIES

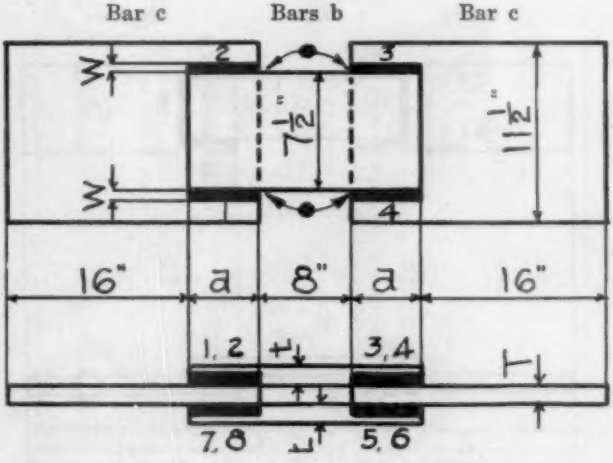
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld a	Weld W	For Arc Welding Amp.	For Arc Welding Size of Wire	For Arc Welding No. of Layers
2322	1/4	3/8	2	1/4	160	5/32	1
2333	3/8	1/2	2	3/8	200	3/16	1
2344	1/2	3/4	2	1/2	200	3/16	2
2355	5/8	3/4	2	5/8	225	3/16	2
2366	3/4	1	2	3/4	225	3/16	3
2343	1/2	3/4	3	3/8	200	3/16	1
2353	5/8	3/4	4	3/8	225	3/16	1
2363	3/4	1	4	3/8	225	3/16	1

General Instructions: Order of welding (arc and gas) No. 1, 2—3, 4. Tack or clamp for arc welding, clamp for gas welding.

Specimens of 2400 Series

Double Strap with Fillets in Parallel Shear.



SPECIMENS OF 2400 SERIES

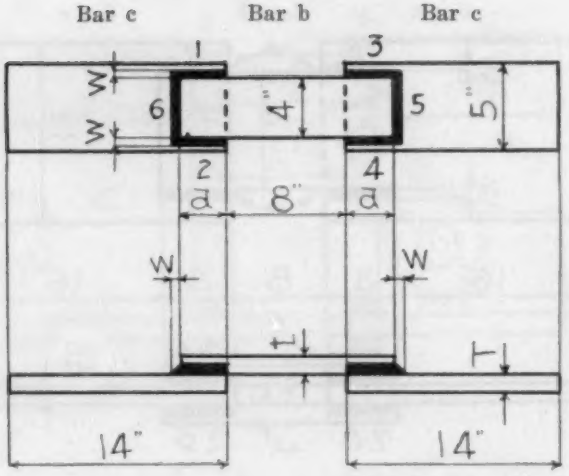
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld a	Weld W	For Arc Welding Amp.	For Arc Welding Size of Wire	For Arc Welding No. of Layers
2433	⅜	½	6	⅜	200	5/16	1
2443	½	¾	8	⅜	200	5/16	1
2453	⅝	1	10	⅜	225	5/16	1
2463	¾	1	12	⅜	225	5/16	1

General Instructions: Order of welding (arc and gas) No. 1, 2—3, 4, 5, 6—7, 8. Tack or clamp for arc or gas welding. Tacking if used at points marked ●→

Specimens of 2500 Series

Single Strap with Fillets in Combined Shear.



SPECIMENS OF 2500 SERIES

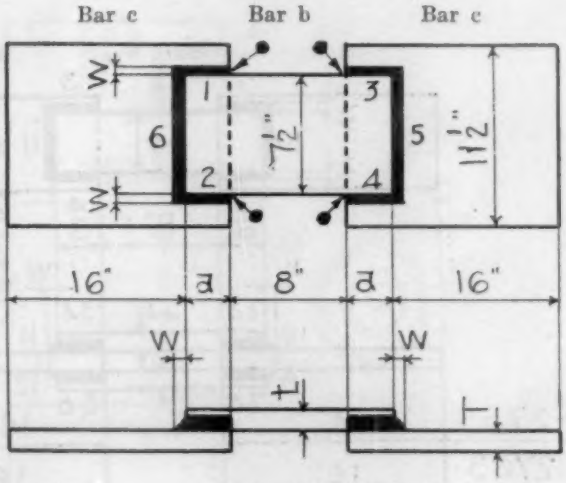
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld a	Weld W	For Arc Welding Amp.	For Arc Welding Size of Wire	For Arc Welding No. of Layers
2543	½	¾	2	⅜	200	5/16	1
2553	⅝	¾	3	⅜	225	5/16	1
2563	¾	1	4	⅜	225	5/16	1

General Instructions: Order of welding No. 1, 2, 6—3, 4, 5. Clamp or tack for arc welding. Clamp for gas welding.

Specimens of 2600 Series

Single Strap with Fillets in Combined Shear.



SPECIMENS OF 2600 SERIES

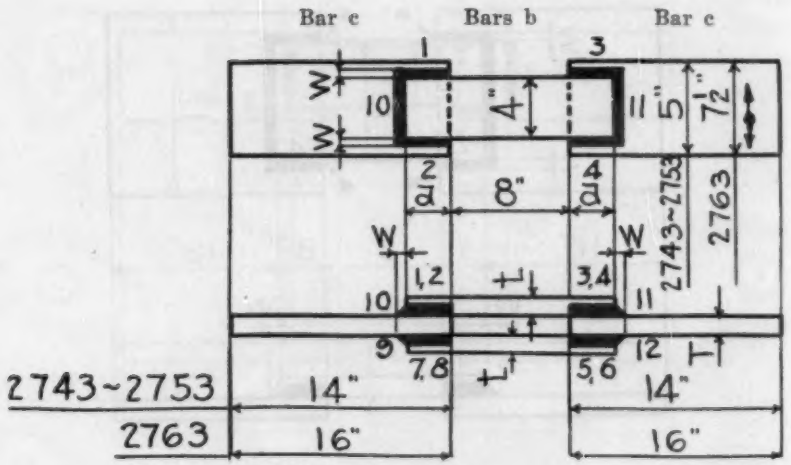
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld a	Weld W	For Arc Welding Amp.	For Arc Welding Size of Wire	For Arc Welding No. of Layers
2633	3/8	3/8	2	3/8	200	5/16	1
2643	1/2	1/2	4	3/8	200	5/16	1
2653	5/8	3/4	6	3/8	200	5/16	1
2663	3/4	3/4	8	3/8	225	5/16	1

General Instructions: Order of welding 1, 2, 6, 3, 4, 5. Tack at points marked ● ⟶ for arc or gas welding.

Specimens of 2700 Series

Double Strap with Fillets in Combined Shear.



SPECIMENS OF 2700 SERIES

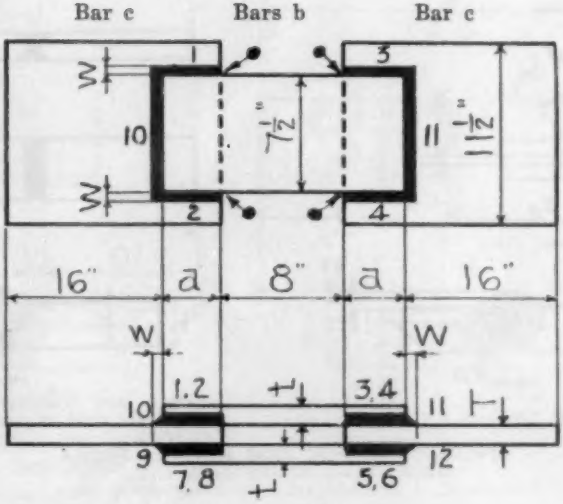
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld a	Weld W	For Arc Welding Amp.	For Arc Welding Size of Wire	For Arc Welding No. of Layers
2743	½	1	2	⅜	200	3/16	1
2753	⅝	1	3	⅜	225	3/16	1
2763	¾	1	4	⅜	225	3/16	1

General Instructions: Order of welding No. 1, 2, 10—3, 4, 11—7, 8, 9—5, 6, 12. Clamp or tack for arc welding. Clamp for gas welding.

Specimens of 2800 Series

Double Strap with Fillets in Combined Shear.



SPECIMENS OF 2800 SERIES

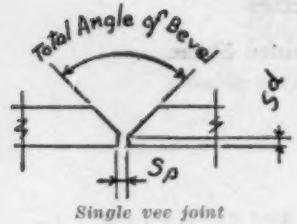
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld a	Weld W	For Arc Welding Amp.	For Arc Welding Size of Wire	For Arc Welding No. of Layers
2833	⅜	½	2	⅜	200	5/16	1
2843	½	¾	4	⅜	200	5/16	1
2853	⅝	1	6	⅜	225	5/16	1
2863	¾	1	8	⅜	225	5/16	1

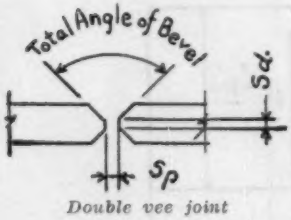
General Instructions: Order of welding 1, 2—10, 3, 4, 11, 7, 8, 9, 5, 6, 12. Tack for arc and gas welding at points marked ●→ both sides.

Specimens of 2900, 3000 and 3100 Series

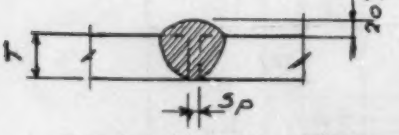
Butt Joint—Continuous Welds.



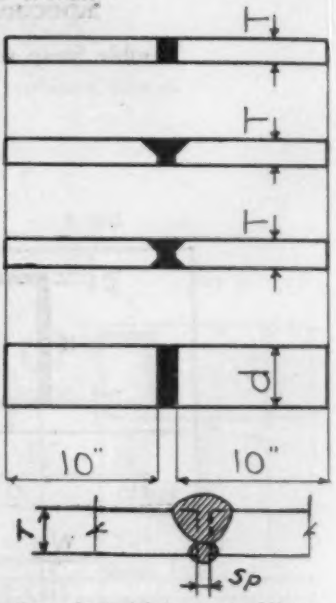
Single vee joint



Double vee joint



Open butt joint—gas welding



Open butt joint—arc welding—light weld on opposite side

SPECIMENS OF 2900, 3000 AND 3100 SERIES

All dimensions in table are in inches

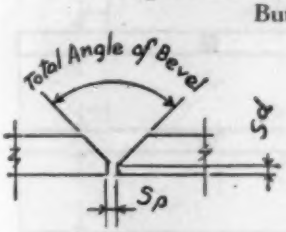
Mk.	Bar C	Weld			For Arc Welding				For Gas Welding		Sd.
	T	d	Type of Joint	Amp.	Size of Wire	Total Angle	Sp.	No. of Layer	Total Angle	Sp.	
2922	1/4	4	Open butt	175	5/32	.....	1/4	1	.....	1/8	....
2933	3/8	4	Open butt	225	3/16	.....	3/8	1	.....	3/16	....
3033	3/8	4	Single vee	200	3/16	75°	3/16	1	90°	1/16	1/16
3044	1/2	4	Single vee	200	3/16	75°	3/16	2	90°	1/16	1/16
3055	5/8	4	Single vee	200	3/16	75°	3/16	2	90°	1/8	1/16
3066	3/4	4	Single vee	200	3/16	75°	3/16	3	90°	1/8	1/16
3144	1/2	4	Double vee	200	3/16	75°	3/16	1	90°	1/8	1/16
3155	5/8	4	Double vee	200	3/16	75°	3/16	1	90°	1/8	1/16
3166	3/4	4	Double vee	200	3/16	75°	3/16	1	90°	1/8	1/16
3177	7/8	4	Double vee	200	3/16	75°	3/16	1	90°	1/8	1/16
3188	1	5	Double vee	200	3/16	75°	3/16	2	90°	3/16	1/16

General Instructions for 2900 and 3000 series. Provide backing (for 2900 series) for arc welding. Clamp for arc and gas welding. Maximum reinforcement about 20 per cent of T for arc and gas welding.

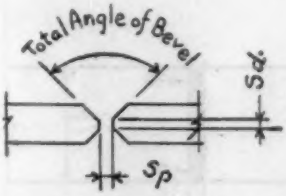
General Instructions for 3100 series. Clamp for arc and gas welding. Reinforce each side 15 per cent of T (max.) for arc and gas welding.

Specimens of 3200, 3300 and 3400 Series

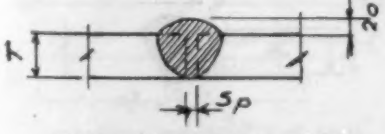
Butt Joint—Intermittent Welds.



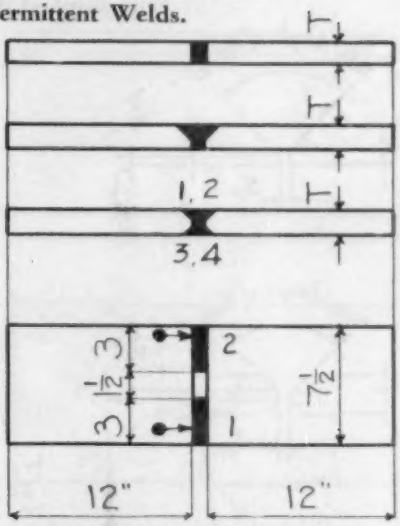
Single vee joint

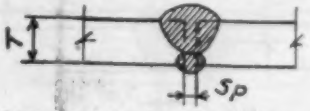


Double vee joint



Open butt joint—gas welding





Open butt joint—arc welding—light weld on opposite side

SPECIMENS OF 3200, 3300 AND 3400 SERIES

All dimensions in table are in inches

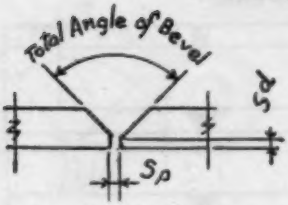
Mk.	Bar C	Weld	For Arc Welding					Gas Welding		Sd.
	T	Type of Joint	Amp.	Size of Wire	Total Angle	Sp.	No. of Layers	Total Angle	Sp.	
3233	3/8	Open butt	225	5/16	.....	3/8	1	.....	3/16	.....
3333	3/8	Single vee	200	5/16	75°	3/16	1	90°	1/16	1/16
3344	1/2	Single vee	200	5/16	75°	3/16	2	90°	1/16	1/16
3355	5/8	Single vee	200	5/16	75°	3/16	2	90°	1/8	1/16
3366	3/4	Single vee	200	5/16	75°	3/16	3	90°	1/8	1/16
3444	1/2	Double vee	200	5/16	75°	3/16	1	90°	1/8	1/16
3455	5/8	Double vee	200	5/16	75°	3/16	1	90°	1/8	1/16
3466	3/4	Double vee	200	5/16	75°	3/16	1	90°	1/8	1/16
3477	7/8	Double vee	200	5/16	75°	3/16	1	90°	1/8	1/16
3488	1	Double vee	200	5/16	75°	3/16	2	90°	3/16	1/16

General Instructions for 3200 and 3300 series. Clamp or tack at ends at points marked ●→ for arc and gas welding; reinforce 20 per cent T (max.). In 3200 series provide backing for arc welding.

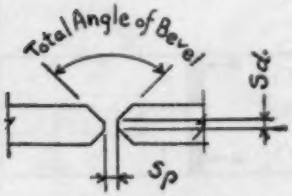
General Instructions for 3400 series. Clamp or tack at ends at points marked ●→ for arc welding, tacking not recommended for gas welding. Reinforce 15 per cent of T (max.) each side for arc and gas welding. Order of welding (arc and gas) 1, 2—3, 4.

Specimens of 3500, 3600 and 3700 Series

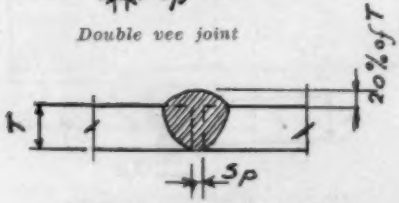
Butt Joint—Continuous Welds.



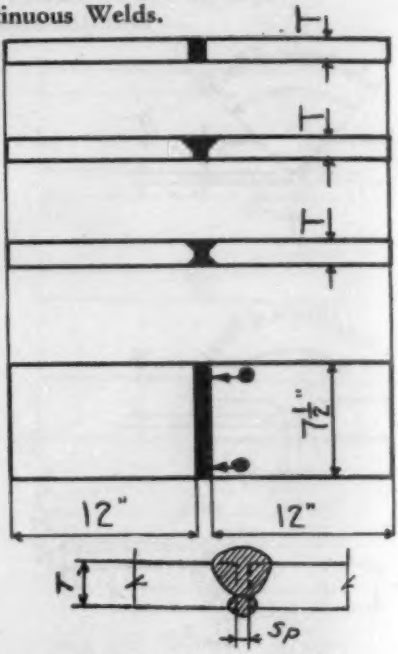
Single vee joint



Double vee joint



Open butt joint—gas welding



Open butt joint—arc welding—light weld on opposite side

SPECIMENS OF 3500, 3600 AND 3700 SERIES

All dimensions in table are in inches

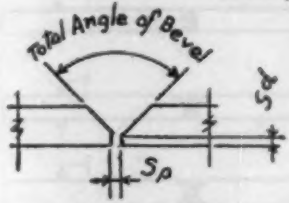
Mk.	Bar C	Weld	For Arc Welding					Gas Welding		Sd.
	T	Type of Joint	Amp.	Size of Wire	Total Angle	Sp.	No. of Layers	Total Angle	Sp.	
3522	1/4	Open butt	175	5/32	.....	1/4	1	.....	1/8	.....
3533	3/8	Open butt	225	3/16	.....	3/8	1	.....	3/16	.....
3633	3/8	Single vee	200	3/16	75°	3/16	1	90°	1/16	1/16
3644	1/2	Single vee	200	3/16	75°	3/16	2	90°	1/16	1/16
3655	5/8	Single vee	200	3/16	75°	3/16	2	90°	1/8	1/16
3666	3/4	Single vee	200	3/16	75°	3/16	3	90°	1/8	1/16
3744	1/2	Double vee	200	3/16	75°	3/16	1	90°	1/8	1/16
3755	5/8	Double vee	200	3/16	75°	3/16	1	90°	1/8	1/16
3766	3/4	Double vee	200	3/16	75°	3/16	1	90°	1/8	1/16
3777	7/8	Double vee	200	3/16	75°	3/16	1	90°	1/8	1/16
3788	1	Double vee	200	3/16	75°	3/16	2	90°	3/16	1/16

General Instructions for 3500 and 3600 series. Clamp or tack at points marked ●→ for arc and gas welding. Reinforce 20 per cent of T (max.) for arc and gas welding. Provide backing in 3500 series for arc welding.

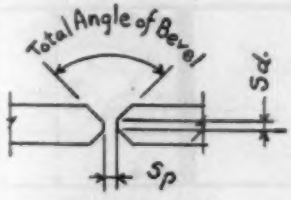
General Instructions for 3700 series. Clamp or tack at points marked ●→ for arc and gas welding. Reinforce 15 per cent of T (max.) each side for arc and gas welding.

Specimens of 3800, 3900 and 4000 Series

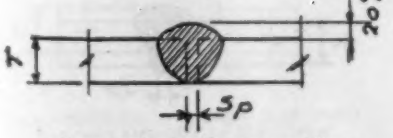
Butt Joint—Intermittent Welds.



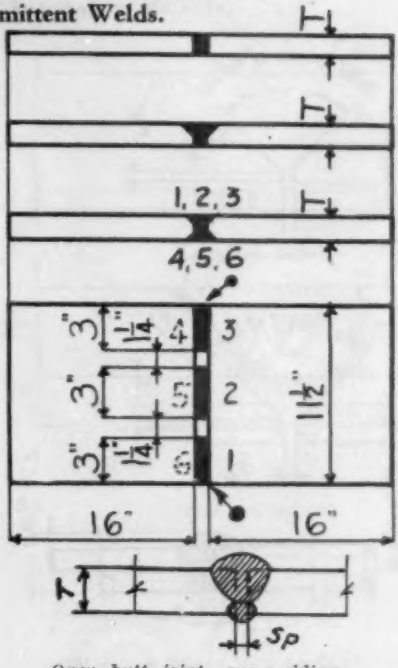
Single vee joint



Double vee joint



Open butt joint—gas welding



Open butt joint—arc welding—light weld on opposite side

SPECIMENS OF 3800, 3900 AND 4000 SERIES

All dimensions in table are in inches

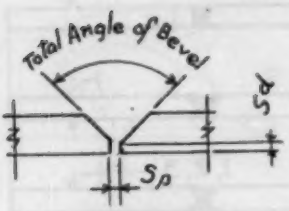
Mk.	Bar C	Weld	For Arc Welding					Gas Welding		Sd.
	T	Type of Joint	Amp.	Size of Wire	Total Angle	Sp.	No. of Layers	Total Angle	Sp.	
3822	¼	Open butt	175	5/32	.....	¼	1	.....	⅛	.....
3833	⅜	Open butt	225	3/16	.....	⅜	1	.....	3/16	.....
3933	⅜	Single vee	200	3/16	75°	3/16	1	90°	1/16	1/16
3944	½	Single vee	200	3/16	75°	3/16	2	90°	1/16	1/16
3955	⅝	Single vee	200	3/16	75°	3/16	2	90°	⅛	1/16
3966	¾	Single vee	200	3/16	75°	3/16	3	90°	⅛	1/16
4044	½	Double vee	200	3/16	75°	3/16	1	90°	⅛	1/16
4055	⅝	Double vee	200	3/16	75°	3/16	1	90°	⅛	1/16
4066	¾	Double vee	200	3/16	75°	3/16	1	90°	⅛	1/16
4077	⅞	Double vee	200	3/16	75°	3/16	1	90°	⅛	1/16
4088	1	Double vee	200	3/16	75°	3/16	2	90°	3/16	1/16

General Instructions for specimens of 3800 and 3900 series (arc and gas welding). Tack at points marked ●→. Reinforce 20 per cent of T (max.). Order of welding 1, 2, 3. Provide backing for arc welding in 3800 series.

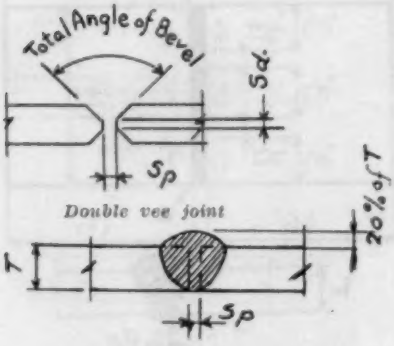
General Instructions for specimens of 4000 series (arc and gas welding). Tack at points marked ●→. Order of welding 1, 2, 3—4, 5, 6. Reinforce 15 per cent of T (max.) each side.

Specimens of 4100, 4200 and 4300 Series

Butt Joint—Continuous Welds.

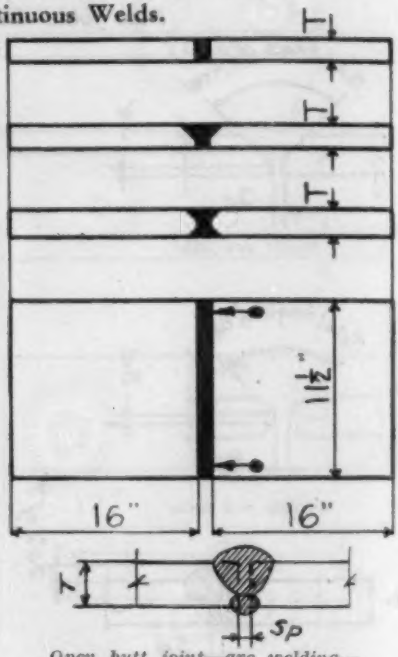


Single vee joint



Double vee joint

Open butt joint—gas welding



Open butt joint—arc welding—light weld on opposite side

Specimens of 4100, 4200 and 4300 Series

All dimensions in table are in inches

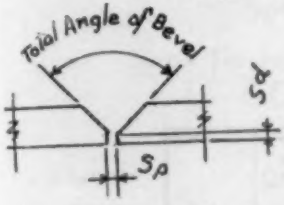
Mk.	Bar C	Weld	For Arc Welding					Gas Welding		Sd.
	T	Type of Joint	Amp.	Size of Wire	Total Angle	Sp.	No. of Layers	Total Angle	Sp.	
4122	1/4	Open butt	175	5/32	.....	1/4	1	.....	1/8	.....
4133	3/8	Open butt	225	5/16	.....	3/8	1	.....	3/16	.....
4233	3/8	Single vee	200	5/16	75°	3/16	1	90°	1/16	1/16
4244	1/2	Single vee	200	5/16	75°	3/16	2	90°	1/16	1/16
4255	5/8	Single vee	200	5/16	75°	5/16	2	90°	1/8	1/16
4266	3/4	Single vee	200	5/16	75°	5/16	3	90°	1/8	1/16
4344	1/2	Double vee	200	5/16	75°	5/16	1	90°	1/8	1/16
4355	5/8	Double vee	200	5/16	75°	5/16	1	90°	1/8	1/16
4366	3/4	Double vee	200	5/16	75°	5/16	1	90°	1/8	1/16
4377	7/8	Double vee	200	5/16	75°	5/16	1	90°	1/8	1/16
4388	1	Double vee	200	5/16	75°	5/16	2	90°	5/16	1/16

General Instructions for 4100 and 4200 series (arc and gas). Reinforce 20 per cent of T (max.). Tack at points marked ●→. Provide backing for arc welding of 4100 series.

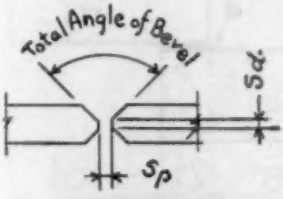
General Instructions for 4300 series (arc and gas welding). Reinforce 15 per cent of T (max.) each side. Tack at points marked ●→.

Specimens of 4400 to 5200 (Incl.) Series

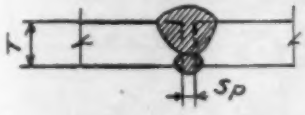
Diagonal Butt Joints—Intermittent Welds.



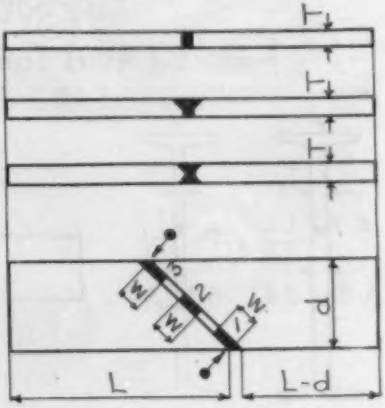
Single vee joint

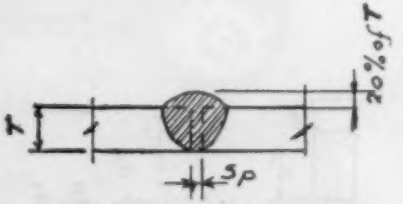


Double vee joint



Open butt joint—arc welding—light weld on opposite side





Open butt joint—gas welding

Specimens of 4400 to 5200 Series, Inclusive

All dimensions in table are in inches

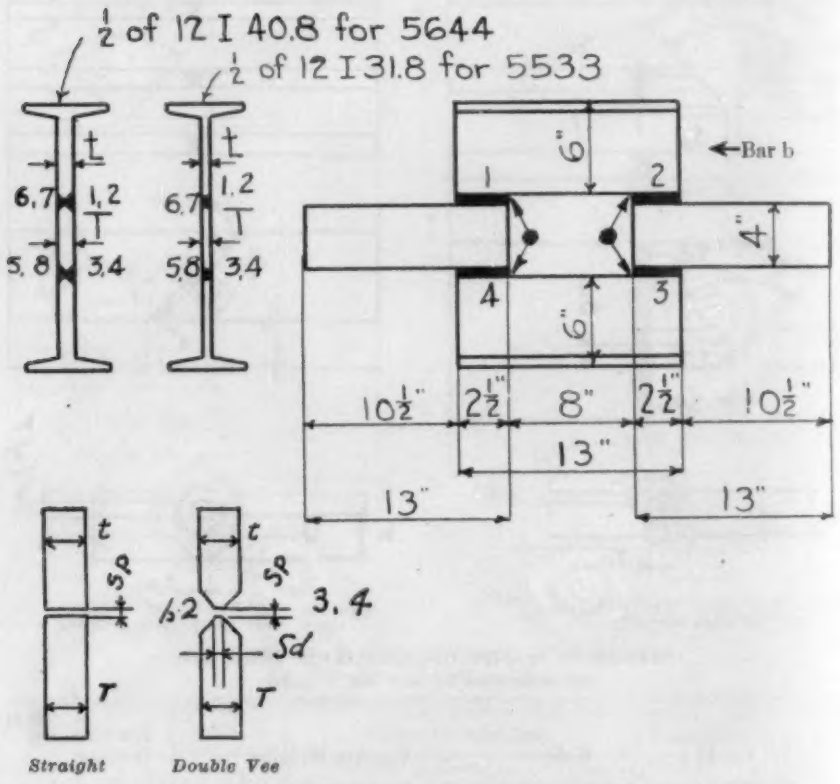
Mk.	Bar C			Weld		For Arc Welding					For Gas Welding		Sd.
	D	T	L	Type of Joint	W	Amp.	Size of Wire	Total Angle	Sp.	No. of Layers	Total Angle	Sp.	
4422	4	1/4	14	Open butt	1	175	5/32	.....	1/4	1	.....	1/8	....
4744	4	1/2	14	Single vee	1	200	3/16	75°	3/16	2	90°	1/16	1/16
5088	5	1	14	Double vee	1	200	3/16	75°	3/16	2	90°	3/16	1/16
4522	7 1/2	3/8	19 1/2	Open butt	2	225	3/16	.....	3/8	1	.....	3/16	....
4844	7 1/2	1/2	19 1/2	Single vee	2	200	3/16	75°	3/16	2	90°	1/16	1/16
5188	7 1/2	1	19 1/2	Double vee	2	200	3/16	75°	3/16	2	90°	3/16	1/16
4622	11 1/2	1/4	27 1/2	Open butt	3	175	5/32	.....	1/4	1	.....	1/8	....
4944	11 1/2	1/2	27 1/2	Single vee	3	200	3/16	75°	3/16	2	90°	1/16	1/16
5288	11 1/2	1	27 1/2	Double vee	3	200	3/16	75°	3/16	2	90°	3/16	1/16

General Instructions for 4400 to 4900 series (arc and gas). Reinforce 20 per cent of T (max.). Tack at points marked ●→. Provide backing for arc welding in "open butt" joints. Order of welding 1, 2, 3.

General Instructions for 5000, 5100 and 5200 series (arc and gas). Reinforce 15 per cent of T (max.) each side. Tack as shown by ●→. Order of welding 1, 2, 3—4, 5, 6.

Specimens of 5500, 5600 Series

Edge to edge Butt Welds in Parallel Shear Double.



SPECIMENS OF 5500 AND 5600 SERIES

All dimensions in table are in inches

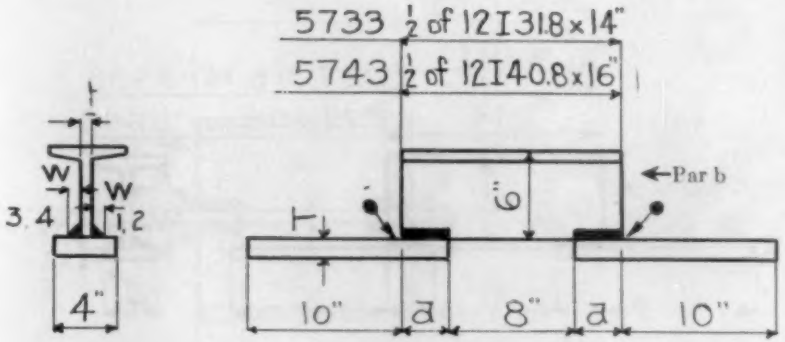
Mk.	Bar b	Bar c	For Arc Welding					For Gas Welding		Sd.
	t	T	Amp.	Size of Wire	Total Angle	Sp.	No. of Layers	Total Angle	Sp.	
5533	⅜	⅜	175	5/32	.....	⅜	1	.....	3/16	.....
5644	½	½	200	3/16	75°	3/16	1	90°	⅛	1/16

General Instructions: (Arc and gas) 5500 series. Provide backing for arc welding. Reinforce 20 per cent of T (max.). Order of welding 1, 2, 3, 4. Tack at points marked ●⟶. Webs horizontal during welding.

General Instructions: (Arc and gas) 5600 series. Reinforce 15 per cent of T (max.) each side. Tack as shown. Order of welding 1, 2, 3, 4—5, 6, 7, 8. Webs horizontal during welding.

Specimens of 5700 Series

Single Tee Joint with Fillet Welds in Parallel Shear.



SPECIMENS OF 5700 SERIES

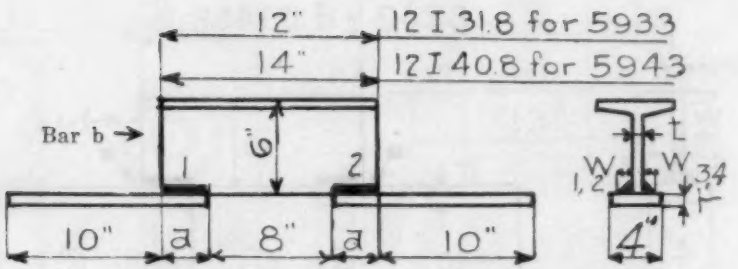
All dimensions in table are in inches

Mk.	Bar b t	Bar c		Weld W	For Arc Welding		
		T	a		Amp.	Size of Wire	No. of Layers
5733	3/8	3/4	3	3/8	200	5/16	1
5743	1/2	3/4	4	3/8	225	5/16	1

General Instructions: Tack at points marked ●⟶ for arc welding, clamp for gas welding. Order of welding 1, 2—3, 4. Web vertical during welding.

Specimens of 5900 Series

Single Tee Joint with Fillet Welds in Parallel Shear.



SPECIMENS OF 5900 SERIES

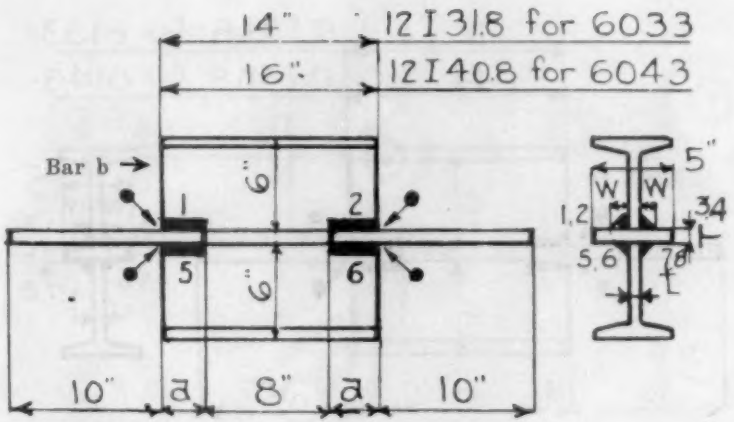
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld a	Weld W	For Arc Welding Amp.	For Arc Welding Size of Wire	For Arc Welding No. of Layers
5933	3/8	3/4	2	3/8	200	5/16	1
5943	1/2	3/4	3	3/8	225	5/16	1

General Instructions: Order of welding 1, 2—3, 4. Clamp or tack for arc welding, clamp for gas welding. Web vertical during welding.

Specimens of 6000 Series

Double Tee Joint with Fillet Welds in Parallel Shear.



SPECIMENS OF 6000 SERIES

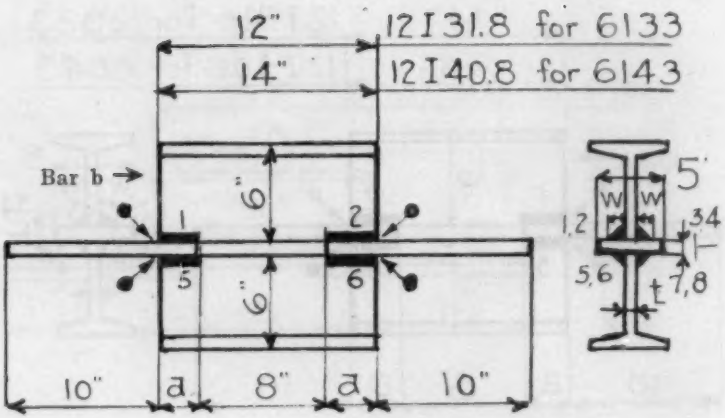
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld		For Arc Welding		
			a	W	Amp.	Size of Wire	No. of Layers
6033	3/8	1	3	3/8	200	3/16	1
6043	1/2	1	4	3/8	225	3/16	1

General Instructions: (Arc and gas). Order of welding 1, 2—3, 4—5, 6—7, 8. Tack at points marked ●→. Turn specimen over to weld opposite side. Webs vertical during welding.

Specimens of 6100 Series

Double Tee Joint with Fillet Welds in Parallel Shear.



SPECIMENS OF 6100 SERIES

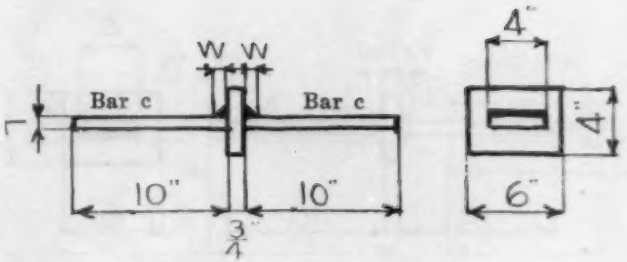
All dimensions in table are in inches

Mk.	Bar b t	Bar c T	Weld a	Weld W	For Arc Welding Amp.	For Arc Welding Size of Wire	For Arc Welding No. of Layers
6133	3/8	3/4	2	3/8	200	5/16	1
6143	1/2	3/4	3	3/8	225	5/16	1

General Instructions: Tack at points marked ●⟶. Order of welding 1, 2—3, 4—5, 6—7, 8. Turn specimen over to weld opposite side. Webs vertical during welding.

Specimens of 6200 Series

Tee Joint with Single Fillets.



SPECIMENS OF 6200 SERIES

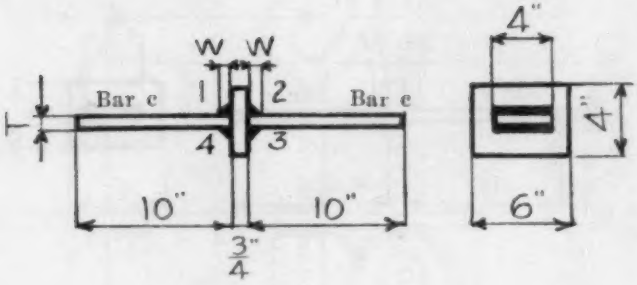
All dimensions in table are in inches

Mk.	Bar c T	Weld W	For Arc Welding		
			Amp.	Size of Wire	No. of Layers
6223	¼	⅜	200	3/16	1
6233	⅜	⅜	200	3/16	1
6243	½	⅜	200	3/16	1
6253	⅝	⅜	200	3/16	1
6263	¾	⅜	225	3/16	1

General Instructions: Tack at ends for arc welding. Block and clamp for gas welding. Bar b vertical during welding.

Specimens of 6300 Series

Tee Joint with Double Fillets.



SPECIMENS OF 6300 SERIES

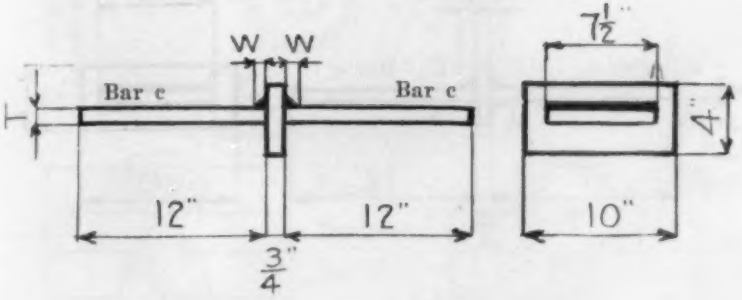
All dimensions in table are in inches

Mk.	Bar c T	Weld W	For Arc Welding		
			Amp.	Size of Wire	No. of Layers
6323	1/4	3/8	200	3/16	1
6333	3/8	3/8	200	3/16	1
6343	1/2	3/8	200	3/16	1
6353	5/8	3/8	225	3/16	1
6363	3/4	3/8	225	3/16	1

General Instructions: Tack at ends for arc welding. Clamp and block for gas welding. Order of welding 1, 2—3, 4. Bar b vertical during welding.

Specimens of 6400 Series

Tee Joint with Single Fillets.



SPECIMENS OF 6400 SERIES

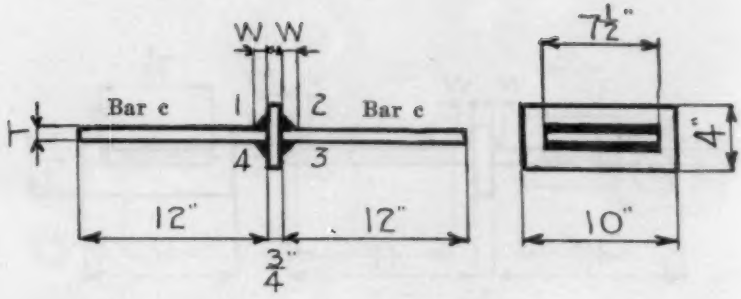
All dimensions in table are in inches

Mk.	Bar c T	Weld W	For Arc Welding		
			Amp.	Size of Wire	No. of Layers
6433	3/8	3/8	200	3/16	1
6443	1/2	3/8	200	3/16	1
6453	5/8	3/8	225	3/16	1
6463	3/4	3/8	225	3/16	1

General Instructions: Tack at ends for arc welding. Block and clamp for gas welding. Bar b vertical during welding.

Specimens of 6500 Series

Tee Joint with Double Fillets.



SPECIMENS OF 6500 SERIES

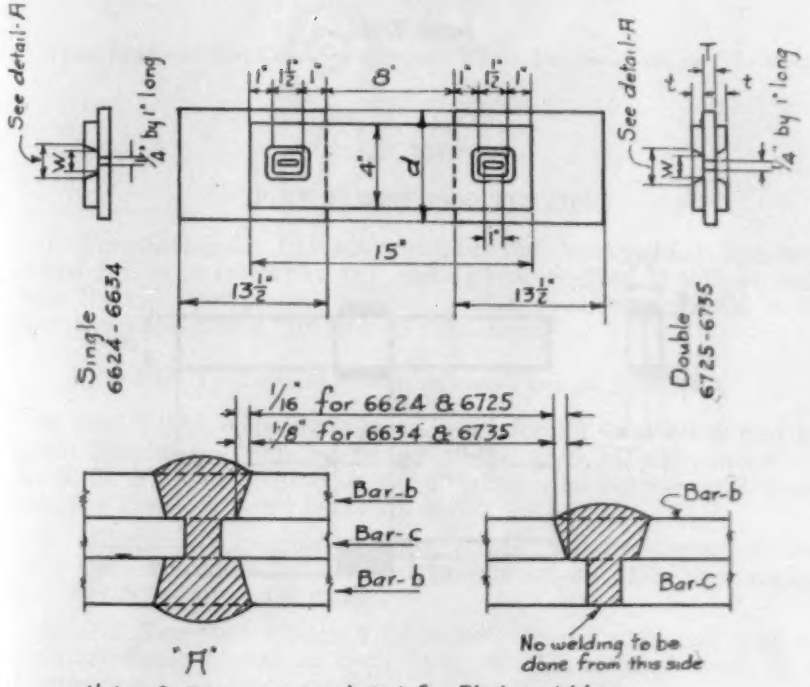
All dimensions in table are in inches

Mk.	Bar c T	Weld W	For Arc Welding		
			Amp.	Size of Wire	No. of Layers
6533	3/8	3/8	200	3/16	1
6543	1/2	3/8	200	3/16	1
6553	5/8	3/8	225	3/16	1
6563	3/4	3/8	225	3/16	1

General Instructions: Tack at ends for arc welding, clamp and block for gas welding. Order of welding 1, 2—3, 4. B bar vertical during welding.

Specimens of 6600 and 6700 Series

Rivet Welds.



Note- C-Bars not to be slotted for Electric Welding.

SPECIMENS OF 6600 AND 6700 SERIES

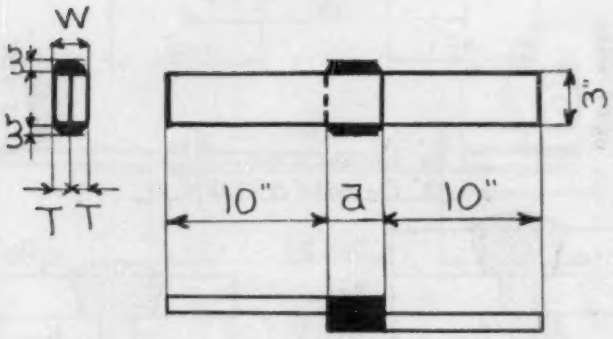
All dimensions in table are in inches

Mk.	Bar b t	Bar c		Weld W	For Arc Welding		
		d	T		Amp.	Size of Wire	No. of Layers
6624	¼	5	⅜	½	175	5/32	1
6634	⅜	5	½	½	175	5/32	2
6725	¼	5	½	5/8	175	5/32	1
6735	⅜	5	¾	5/8	175	5/32	2

General Instructions: Reinforce 10 to 15 per cent of t. Clamp for arc and gas welding. For gas welding of 6600 series, No. 40 drill size tip recommended; preheat under side before welding. Face of specimens to be flat during welding. For 6700 series gas welding No. 50 drill size tips recommended; face of specimens to be vertical during welding to facilitate welding from both sides at once.

Specimens of 6800 and 6900 Series

Band Weld.



SPECIMENS OF 6800 AND 6900 SERIES

All dimensions in table are in inches

Mk.	Bar c		Weld		For Arc Welding		
	T	a	w	W	Amp.	Size of Wire	No. of Layers
6821	¼	2	⅛	½	175	5/32	1
6921	¼	4	⅛	½	175	5/32	1
6842	½	3	¼	1	200	3/16	(beads 3)
6942	½	6	¼	1	200	3/16	(beads 3)

General Instructions: For arc welding, weld may be deposited in a series of lengthwise beads. Clamp specimens. Face of specimens to be vertical during welding so that welds can be made in flat position.

Specifications for Test Specimens—Their Preparation and Testing

SECTION F

PROCEDURE FOR TESTING

1. *Terminology.* In this Section the butt-welded specimens called for in paragraphs (c) and (g) of Section B will be called "qualifying" specimens. All the welded specimens shown in Section E will be called "program" specimens.

Part 1—Tests of Materials and Tests of Specimens

2. *Mill Tests.* The base metal steel for all qualifying and program specimens shall be tested at the mill in accordance with A. S. T. M. specification A-9, and shall also receive mill inspection for freedom from laminations.

3. *Mill Scale.* In order to show strain lines in subsequent tests, care shall be taken at the mill to remove as little mill scale as possible from any base metal.

4. *Mill Reports.* The mill furnishing base metal steel shall furnish triplicate copies of each test report and send them to the Committee.

5. *Mill Samples.* For each melt of steel one sample, 18 inches long, shall be cut by the mill from one end of each different thickness of material and shall be rough machined so as to provide a specimen in accordance with A. S. T. M. specification A-9. Each sample shall be given an identifying mark as it comes from the rolls, and the mill shall advise the Committee what system of marking was employed. These samples shall be shipped by the mill to such laboratories as are designated by the Committee.

6. *Laboratory Check.* From each mill sample the designated laboratory shall machine finish and test one standard A. S. T. M. tensile specimen (8 inch gage) to determine yield point, ultimate strength, elongation in 8 inches, and contraction of area. The yield point shall be determined as specified in paragraph 12 of this Section. As far as practicable all samples shall be tested on the same machine and by the same operators. The portions of samples not required for these tensile specimens shall be reserved at the laboratory for further tests if such are considered necessary.

7. *Filler Metal.* The wire to be used in the arc process shall be tested at the plant where it is manufactured in accordance with

American Welding Society's Specification E 1 A or E 1 B. The wire to be used in the gas process shall be tested by the concern furnishing it in accordance with the first paragraph of Topic 4 of Section C. Triplicate copies of each report on wire shall be furnished by the tester and transmitted to the Committee.

Part 2—Laboratory Equipment and Methods of Testing

8. *Tests to be Made.* Qualifying specimens need only be tested for tensile strength as prescribed on pages 6 and 14 of Section B. It is obviously desirable to obtain the yield point also although no yield point limit is specified for these specimens.

All program specimens are to be tested for tensile strength and yield point—the procedure to be as prescribed herewith.

9. *Inspection of Specimens.* Before testing, the laboratory shall check the specimen identification marks (Section B, Page 6, and Section C, Page 6) and the dimensions of each specimen sent them with those specified by the Committee. This applies both to qualifying and program specimens. The laboratory shall record any discrepancy of more than 0.05 inch in base metal sectional dimensions; the nominal size of actual weld as determined by the gages shown in Figs. 13 and 14, Section C, and the effective length of weld as specified in the Note on the front page of Section E.

10. *Testing Machine.* The laboratory engineer of tests shall inspect the testing machine and convince himself it is in good condition and is properly calibrated. In order to insure axial loading particular attention should be given to the grips for holding the specimen. This can be done by inserting the flat wedge grips in the machine and applying a load of, say, 20,000 lbs. upon a bar about one inch in diameter and two feet long. This bar should be in the axis of the machine and be gripped along the middle of the face of the grips. Care should be taken that the inside ends of the two grips in each head are in the same plane. With the load on the bar the inner faces of the grips must be parallel. This can be determined by using inside calipers. Feelers should be used to detect any opening between the backs of the grips and the head. If the grips are not parallel, or do not bear against the head, the opening in the head must be machined so as to insure axial loading of the specimen.

11. *Speed of Testing.* The various speeds of the removable head of the testing machine (screw type) shall be determined with no specimen in the machine and recorded. In the testing of specimens, the speed at all times shall be such as will allow the operator to keep the beam balanced so that the load on the specimen can be read accurately and the behavior of the specimen observed. Up to the yield point the speed shall not exceed $\frac{3}{8}$ in. per minute. Above the yield point the speed may be increased if desired. For most screw machines, the "second speed" (next faster than the slowest) should meet these requirements up to the yield point.

If necessary the machine may be stopped at intervals in order to permit the recording of strain lines on welded specimens.

12. *Yield Point and Tensile Strength.* In all welded specimens, the yield point shall be determined by very carefully observing the "drop of the beam." After the yield point has been determined the load shall be then increased until the specimen fails and the ultimate load recorded. A record shall also be made of the load at which any one of the welds in the specimen fails or shows unusual behavior.

13. *Adjustment of Specimens.* Each program specimen shall be placed in the testing machine so that the right and left ends, as they appear in Section E, are gripped axially, and so that the inner ends of the grips are in the same plane when under an initial load of 1000 lbs. Specimens shall be located in the machine so that the clearance from the inner end of each grip to the center of butt welds, or to the end of the "b" bars in the case of other welds, shall be 4 inches.

14. *Whitewash.* All specimens should receive careful inspection for surface strain lines while under test and upon completion of test. In order that strain lines may be more readily seen and photographed when desired, the surface of all specimens shall be coated, prior to testing, with a thin mixture of water and white portland cement, using a soft brush. Before this whitewash is applied any rust or grease shall be removed from the surface of specimen, but mill scale should be left on.

15. *Reports of Tests.* After testing, the specimen shall be removed and, in case any broken part bears no specimen identification mark, its proper mark shall be stamped thereon. The committee will furnish each laboratory with a supply of log and report sheets on which all data and any significant behavior of specimens shall be recorded. The development of strain lines shall be observed during the progress of the tests, and reported. Particular attention should be given to strain lines on the surface of welds, for the reason that they are not readily noticeable. If strain line development is similar in a group of specimens a general report for each such group will be sufficient, but abnormal cases should be especially noted. Photographs or sketches of significant cases should be made. The nature and location of the fracture of each specimen must be described, if necessary with the aid of sketches. Weld fractures should be most carefully inspected, and reports made as to the features listed in Section B, Pages 3 and 11, Item (c), as well as any insufficient depth of fusion, or of penetration at the root of the weld.

Arc Welding Breaker Trucks*

By W. H. Himes†

APPLICATION of welding methods to the construction of truck-type oil switches requires rather more daring than might generally be supposed. These switches are safety devices with drastic interchangeability requirements, for as many as thirty units are used in one switch structure.

The cell structures, which are factory-made and shipped ready to bolt to the powerhouse floor, must not only adjoin each other exactly so as to present a neat front when the trucks are in place, but they must also align with the holes in the powerhouse floor or overhead structure previously prepared for the individual leads for each breaker. Thus the requirements are maximum of mechanism in a given space, assured alignment with previously installed lead openings and foundation holes, uniform front appearance and assured interchangeability of all trucks in all cells.

When this line of switchgear was first introduced, welding was tried tentatively and abandoned, as the shop reported that no two structures could be made alike on account of warpage. Riveting was also tried and abandoned. The structure finally developed, which could be produced interchangeably, was a rather complex bolted frame of angle iron and malleable corner castings having machined surfaces. This construction, although fairly effective, was expensive, and when a new design was determined on a careful study of requirements, as well as of various types of construction, was made. In spite of the conviction in the shop that welding was out of the question, its advantages loomed large and a tentative design of welded structures for both truck and cell was worked out. The chief requirements involved were economical manufacture, assured interchangeability, sufficient strength for rigidity in shipping and in service, and ease of erection and service.

The First Experiment

In the construction of the first sample the tendency to warp was the main problem. It was early determined to make the sides of the truck structure as individual panels, welding the elements together while they were clamped to a heavy bedplate. The stresses to which the frame was to be subjected rendered it desirable to provide bracing similar to that shown in Fig. 1. The various elements shown in this figure were clamped securely to the bedplate and the welder started around the structure, finishing the welds in rotation. When finished, it was found that while the clamping had provided a frame that would lie fairly flat on the table, the front member (a) was drawn out of true in the plane of the figure

*Abstract of paper submitted to the A.S.M.E., in competition for the Lincoln arc-welding prize for 1927. Reprinted from Oct. 20, 1928, issue *Electrical World*.

†Wilkinsburg, Pa.

by the diagonal braces. Repeated trials developed the fact that the nature of the deflection could be altered by the sequence of the welds. The requirements for a satisfactory panel were simply that it should lie flat on the bedplate when free and that the front member (a) should be so straight that its out-turned flange would fit snugly against the

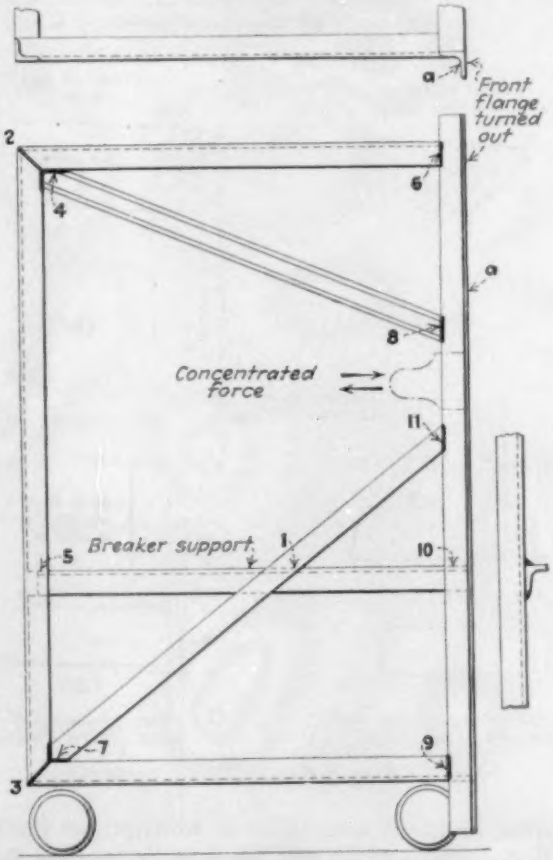


FIG. 1. TRUCK BRACED FOR ARC-WELDING FABRICATION

cell edges when the complete truck was pressed into position. This meant a maximum variation from normal of 1/16 in. The rear uprights might depart from the vertical by ⅛ in. in their length without serious results. Also, an exact right angle for the horizontal members was not necessary. Flexibility in this regard had been provided by the new design of adjustable wheel brackets.

Thus the welding problem consisted in finding the sequence which would throw the least distortion into the front member. The following sequence was worked out and found to give excellent results:

The lower diagonal was first welded to the horizontal member at 1.

While this was cooling, the upper rear corner was welded at 2, next the lower rear corner at 3. Returning to the upper corner, the diagonal was welded at 4. The remaining joints were welded in the sequence indicated by their numbers. It will be noted that by the time 7 was finished the rear upright had been completely tied into the cross-members in such a sequence as to reduce to a minimum the concentration of welding heat. Moreover, the free ends of the cross-members were free to creep

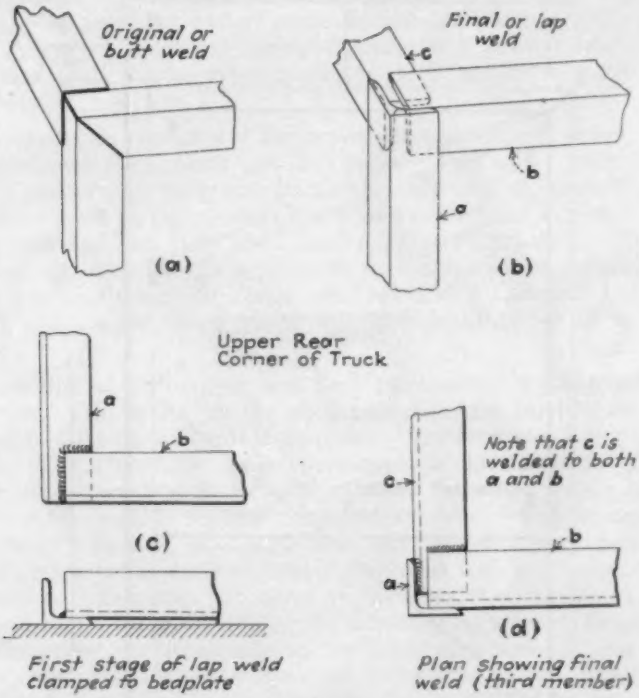


FIG. 2. SOME WELDS IN TRUCK ASSEMBLY

under the clamps to adjust themselves as to length as the welds cooled. Before weld 6 was made, which was the first tie into the front member, the weld 2, at the opposite end of the cross-member, had been cooling during the welding of 3, 4 and 5. During the welding of 1, 5 and 7, which closed a rigid structural triangle, the ends 10 and 11 were clamped so as to hold them tightly against the bed, but to permit free creepage in all directions during the heating and cooling cycle at the other end. These intersecting braces had been one of the chief causes of trouble in the first trials. However, by the new sequence, welds at 8, 9 and 10 gave weld 7 time to cool before 11 at the other end of the diagonal was started. In this way frames that would lie flat on the bedplate were produced which had front members 65 in. long which came within 1/16 in. to 1/32 in. of being straight.

The next and obvious step was to combine a right-hand and a left-hand

frame so constructed into a cubicle structure by welded connecting members. While being so welded the pair of frames were held rigidly in position by very strong braces. The same general principles were followed as with the frames—especially the avoidance of excessive heating due to too prolonged welding work in one place.

Structural Design

Especial attention was given to the design of the different faces of the frame to insure that diagonal bracing should be included in each.

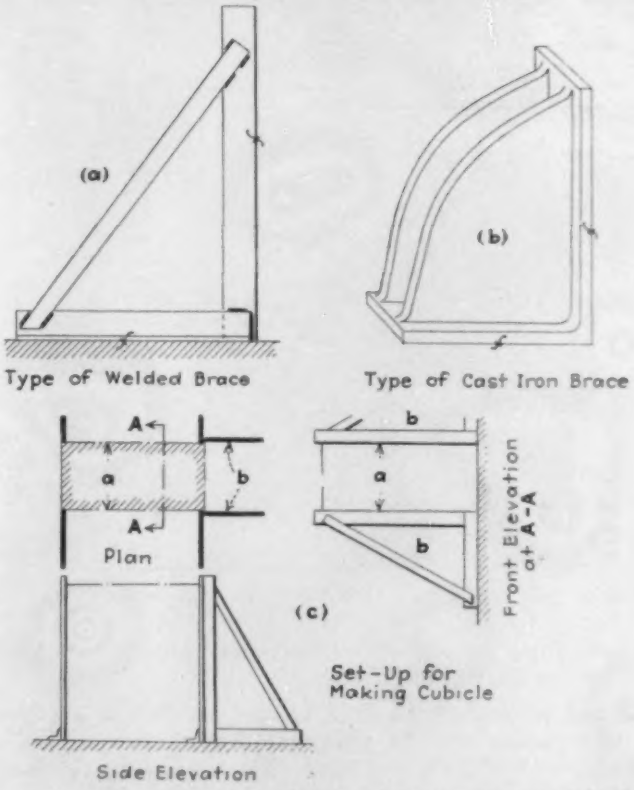


FIG. 3. TYPE OF BRACE USED COMPARED TO CAST-IRON BRACES

Theoretically a cubicle structure can be shown to be rigid if five of the six faces are braced against distortion in their own planes. However, since accessibility required that several of the faces should have generous openings, full bracing as understood in structural design was not possible. In front, for instance, only short diagonal bracing at the four corners could be permitted on account of the meters and other apparatus projecting through openings in the switchboard panel. Therefore, as much bracing was inserted in each of the other five faces as possible and, altogether, a very rigid structure was produced.

Lap joints at the eight corners were used after some study and produced the following beneficial results: The lapped members could be sheared to a 1/16-in. tolerance or even less. Fillet welds were possible instead of butts, which reduced the distortion due to shrinkage of the weld metal. Considerable thought was given to providing joints of such nature that overhead welding was reduced to a minimum.

An important development in the assembly is that several capacities of apparatus may be housed in the same pair of side panels by connecting them together into different widths of cubicle. Once standardized, these panels may be made up in quantities and stocked for future

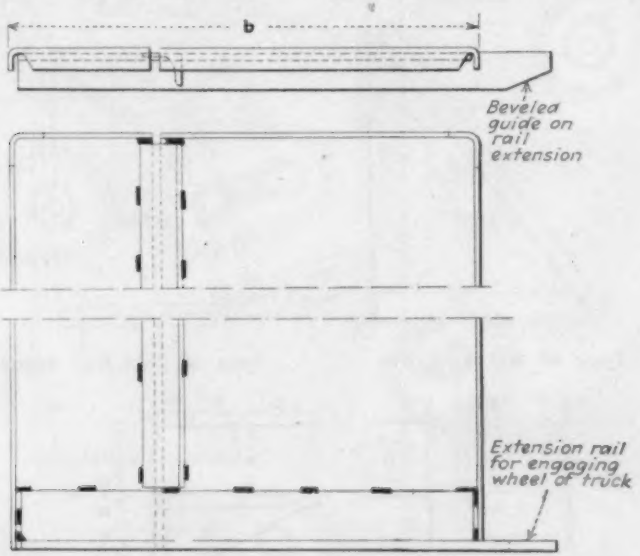


FIG. 4. SIDE MEMBERS OF CELL STRUCTURE TACK-WELDED IN PLACE

assembly according to the orders received, whereas stocking of the assembled cubicle is impracticable.

The diagonal bracing on the sides was a more difficult problem. There was so little clearance for the apparatus that these members could not be lapped and the butt weld was used. The short diagonal braces in the front opening were also put on by means of butt welds.

Mention has been made of the bracing of the first cubical structure during welding. This was by means of temporary braces, but when production was started a series of triangular frames were made up that could be locked rigidly to the bedplate (Fig. 3, *a*). Two pairs of these were set up facing each other on a bedplate (Fig. 3, *b*) with the dimension *a* certified as being the correct width of the truck cube. Two other braces *b* were located at the front. The front edges of the right and left panels were clamped against these latter braces, insuring parallelism of their front edges. The panels were also clamped or wedged against the front and rear side braces and the connecting pieces were

then welded in place. When the frame was finished it was drawn vertically out of the fixture by the crane. Thus the fixture was not disturbed or readjusted after being set up.

An incidental exhibit of the economy of welding as applied to shop fixtures is seen in a comparison of two sets of fixtures. The six braces

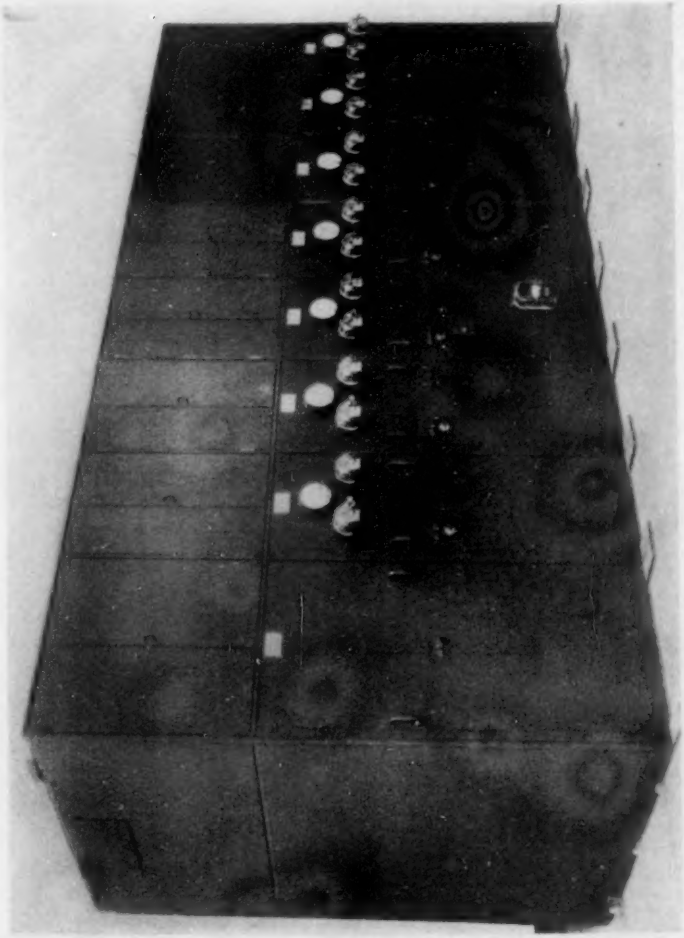


FIG. 5. COMPLETE SWITCH STRUCTURE WITH CELLS IN PLACE

just referred to were fabricated by welding structural shapes. A set previously made for a smaller-sized unit was made of cast iron. These are shown in Fig. 3, *b*. The cost of patterns, castings and machining of this set of eight amounted to over $800, while the welded set previously illustrated was built for less than $150. The latter set was more accurate, of much greater capacity and gave the welder better access to the work. The welded fixtures were constructed in less than one week, while the cast-iron set was two months in process.

Two types of welded cell were considered: First, an angle-iron frame covered with sheet iron; second, a welded-sheet steel cabinet depending as far as possible for rigidity on the flanges bent into the sheets at the corners. A compromise was developed in which the sturdy angle-iron rails of the old design were retained. As with the truck, the two sides

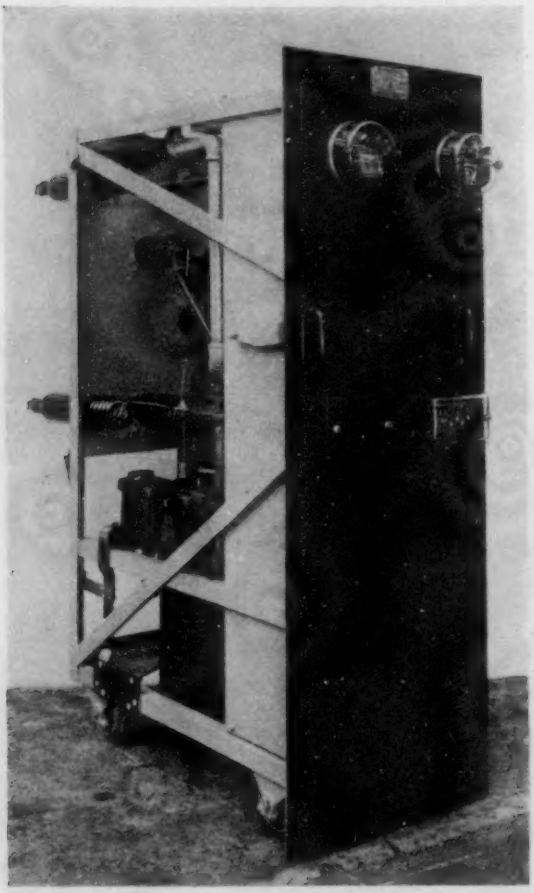


FIG. 6. FRONT VIEW OF WELDED TYPE TRUCK SWITCH

were assembled first (a side is shown in Fig. 4). The object of the vertical angle is to support a removable diaphragm or partition separating the live bus circuit from the breaker compartment. As the distance (*b*) exceeds the standard width of such sheets, this angle makes a convenient position for a joint. With the two sides complete, the following procedure is similar to the track practice; Rigid braces are used to hold the sides in position while the connecting parts are welded in place. It is not necessary to weld continuously along these joints, so a system of

"skip" welding was worked out. Welds of 1 in. to 1¼ in. were made every six inches or so. These give ample strength and do not overheat the metal. A 1-in. weld is about the shortest than can be relied upon.

In general, much less difficulty was encountered with the cell than with the truck. The shop soon learned to make the opposing flanges very

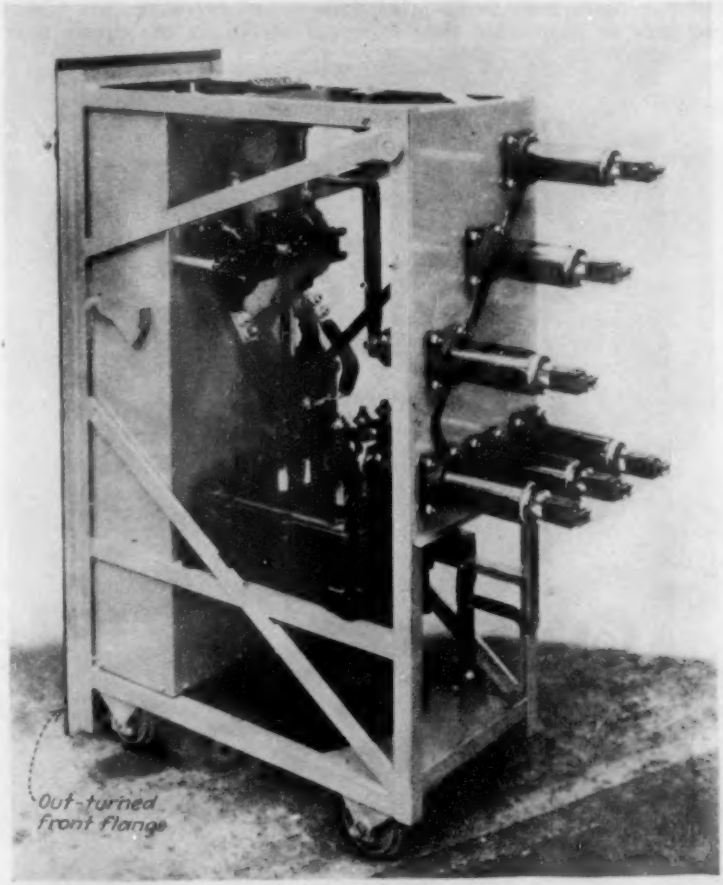


FIG. 6A—REAR VIEW OF WELDED TYPE TRUCK SWITCH

closely to dimension. Besides, the laps on the vertical angle and on the horizontal base angle gave a chance to "go and come" to attain the correct over-all dimensions.

Before the first experimental cell was scrapped permission was secured for a destruction test. It was picked up at one corner by a shop crane and dropped by means of a trigger release from various heights. It was first dropped 9 in. A slight buckle developed at one corner of the roof. It is believed that the cell could have been set up and used after this

first drop. The next drop was from a height of 1½ ft., resulting in a slight increase in the distortion at the same corner but no welds were ruptured.

The next drop was from a height of 5½ ft. The buckling of the roof became more pronounced and also began to develop on the opposite side. The floor plate also began to buckle adjoining point of impact. We were allowed one more test, and it was determined to make this effective, so the cell was so suspended that it would strike on the upper rear edge.

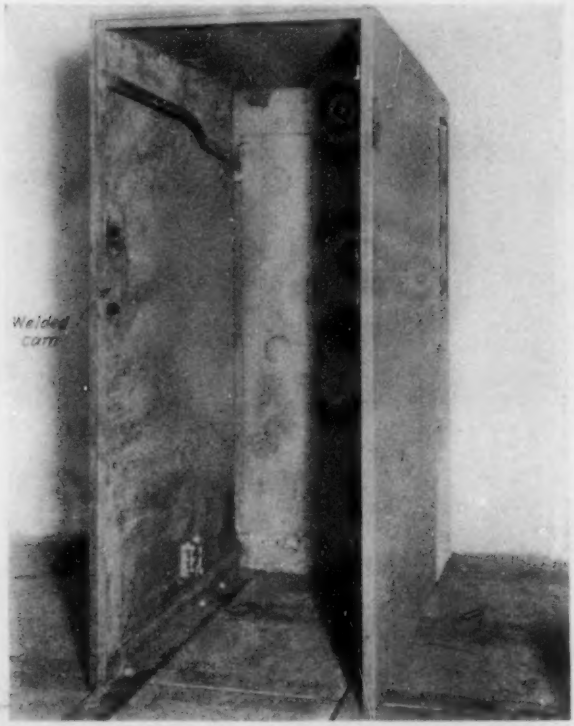


FIG. 7. THE FIRST WELDED CELL

The previous blows were received on the bottom and were probably borne largely by the heavy base angles. The upper rear edge had no backing except a flange in the ⅛-in. sheet.

The last drop was from a height of 20 ft. An accompanying illustration shows the results after this drop. It will be noted that the bottom edge marked *b* was still in good condition, but that the top edge *c* was effectively crushed by the final blow. The displaced pieces showing in the opening are asbestos partitions. In general, the structure showed itself amply strong to stand the most violent handling conceivable in transportation.

Resulting Economies

In the truck and cell together $12 worth of hardware (nut, bolts, etc.) were eliminated by the use of arc welding. In addition, twenty malleable corner castings were being surface-machined on three sides as well as drilled and, in some cases, tapped. A saving on both structures which is impossible to state accurately is in reduced inspection and adjustment expense. This was quite a factor in the old design.

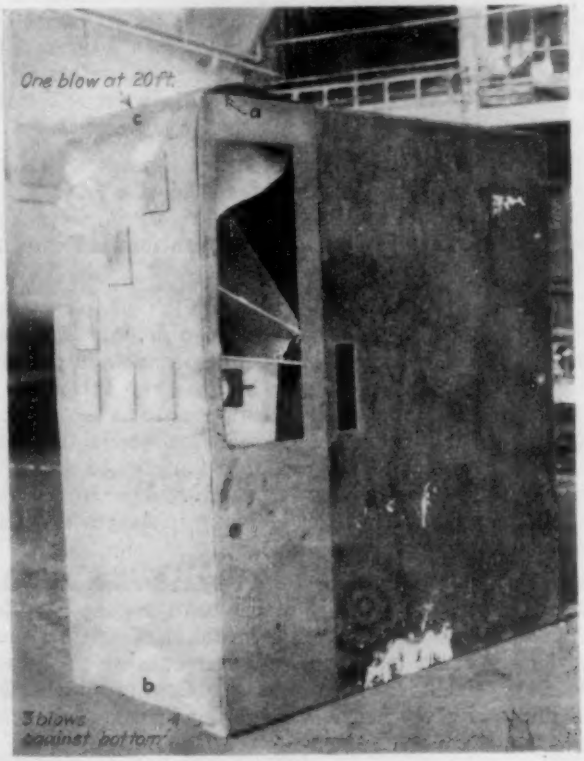


FIG. 8. SWITCH CELL AFTER BEING DROPPED SEVERAL TIMES, FINAL HEIGHT 20 FT.

An advantage which cannot be evaluated in dollars is the reduction of time in process. Layout and drilling time being eliminated, assembly starts as soon as the sheared material is put in the hands of the welder.

The supporting structure with which this paper deals involves a small part of the cost of the complete unit with all of the electrical apparatus installed. However, the economies in the welded structure were so marked as to remove the activity from a position very close to the line between profit and loss to a condition where some profit is shown—this without sacrifice, but with the improvement in the quality of the product.

Oxy-Acetylene for Cutting Structural Steel*

D. E. ROBERTS†

WHEN a structural engineer first becomes interested in the oxy-acetylene process for cutting steel he will probably be interested first in what the oxy-acetylene process will do. Second, how best this process can be employed from the point of view of selecting applications and also of actually doing the work. Third, in what effect the action of cutting with the oxy-acetylene process has upon structural members.

In the structural fabricating shop the usefulness of the oxy-acetylene process will depend to some extent upon the size of the shop and its mechanical equipment. Practically all fabricating shops use the oxy-acetylene process of cutting for some applications. Some use it much more than others, of course.

In many fabricating plants mill run lengths of structural steel are stacked in the yard accessible to handling equipment. The oxy-acetylene cutting blowpipe has been found almost indispensable in the stockyard for cutting these mill-run lengths to size before they enter the fabricating process. This is usually done as close as possible to the stock pile simply by rolling the individual member to the point where they can be effectively cut. For this operation the portability of the oxy-acetylene cutting blowpipe saves considerable handling and makes it possible for the operator to measure off the lengths in many instances exactly where the part is located and cut it to size.

In the shop a wide range of work can be done. Some smaller fabricating shops do practically all of their cutting with the oxy-acetylene process. Others equipped with shears and other mechanical cutting equipment use the oxy-acetylene process only for irregular cuts or for heavy material such as billets and slabs for column bases. Coping and blocking as well as much punching of rivet holes in relatively inaccessible places is done in the fabricating shop with the oxy-acetylene blowpipe.

A number of fabricating shops use the oxy-acetylene cutting outfit to turn the spare time of their operators and short lengths of material into profitable parts such as column brackets.

When steel is sent out for erection there is always a certain amount of trimming to fit. The oxy-acetylene cutting blowpipe will furnish a simple and convenient means of doing extra blocking or coping in the field, punching the rivet holes missed in the shop or trimming lengths for easy fit.

Where structural steel is to be welded, it is even more necessary that the parts fit together with fair accuracy. In instances where the edges are bevelled for welding the oxy-acetylene process of cutting is especially

*Presented at annual meeting of A. W. S., Philadelphia, Oct., 1928.
†Linde Air Products Co., New York.

useful and it can also be used economically to cut out spliced plates and column brackets if these are used.

Training of Operators

The matter of training operators for oxy-acetylene cutting is not at all difficult. Manufacturers of cutting equipment supply standard oxygen

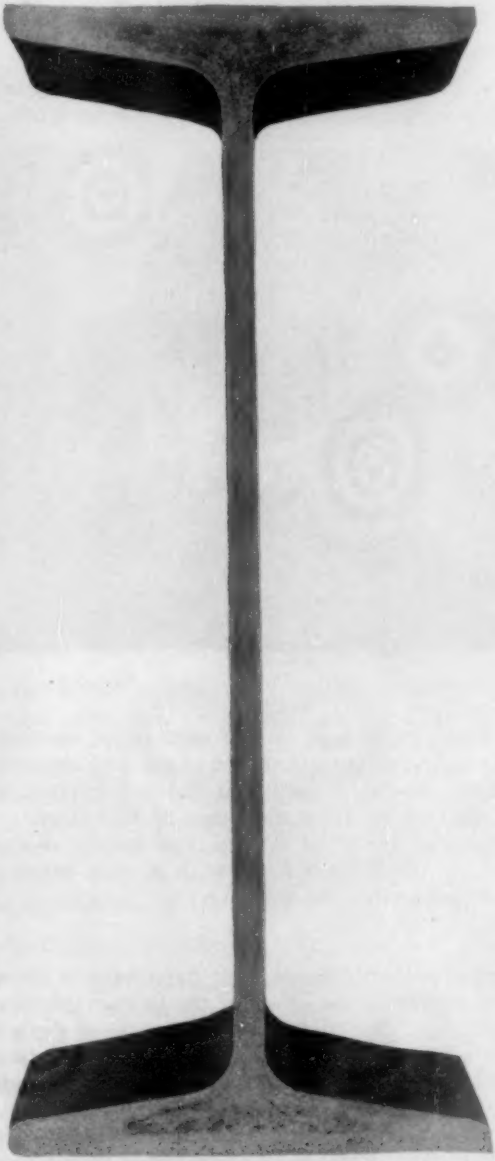


FIG. 1—I-BEAM, POLISHED AND HEAVILY ETCHED. 50 PER CENT NATURAL SIZE

and acetylene pressure for certain thicknesses of metal and these should be used for greatest economy and efficiency. There is a tendency among some operators to use abnormally high oxygen pressures with the feeling that this will make the work more rapid. It results only in a waste of oxygen. By using guides or by carefully following chalk marks on the steel, smooth and very accurate cuts can be made regularly by an operator with a moderate amount of training.

Automatic Machines

There are available now on the market automatic oxy-acetylene cutting machines that are especially valuable for repetitive work. The machines

FIG. 2—TESTING THE BARS IN BENDING

carry a special blowpipe guided in one manner or another and have the advantage of turning out cuts that are exact and exceptionally smooth. Work that requires almost a machined finished surface can be handled with entire satisfaction by some machines of this type.

Where the cut edges are to be welded it is usually desirable to remove the cutting scale by brushing a little with a wire brush. This gives a clean surface for most effective welding.

Effect on Steel

The question that probably looms most important in the minds of structural engineers, however, is the effect of the oxy-acetylene cutting process on the steel itself. In the past in some instances designing engineers have insisted on milling away the cut edges. Exhaustive tests as well as practical work over a period of many years has shown this to be unnecessary. In order to determine definitely whether there is any sound reason for this action, a number of experiments were made in the Union Carbide & Carbon Research Laboratories to compare the physical

properties of structural steel surfaces cut by the several different methods; the oxy-acetylene process, the shear, the milling cutter and the friction saw. The advantages are all in favor of the oxy-acetylene process as will be shown by the summary of the tests which follows:

Pieces of good quality structural material—12 in. I-beams, with web 5/16 in. thick; 4 by 4 by ¼ in. angle irons; and a ⅜ in. steel plate were studied. They were chosen at random and are typical of materials which would be commonly encountered in various structural fabrications.

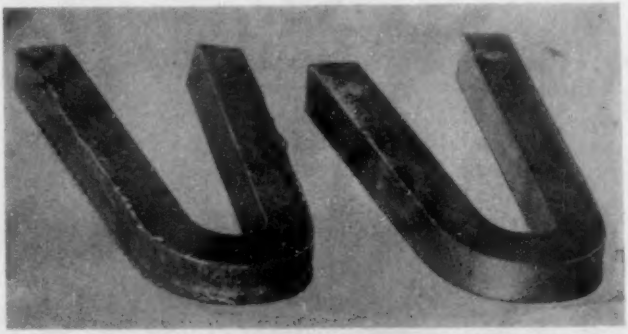


FIG. 3—BENT TEST BARS: LEFT, OXY-ACETYLENE CUT; RIGHT, MACHINED

FIG. 4—TEST BAR, SHEARED FROM PLATE. SURFACE CRACKED ON SLIGHT BEND

One of the I-beams was machined square across, the surface polished, and then pickled for some time in strong acid. This brought out marked differences in metallic structure. As shown in Fig. 1 the web is reasonably free from defects; the central portions of the flanges, however, show a considerable segregation of metallic structures which have been eaten away by the acid much more rapidly than the surrounding metal. All bending specimens were therefore taken from the web of the beam. Similar etching tests on the angle iron and the plate showed sound metal, about the equivalent of the I-beam web.

Comparison With Other Methods

In order to compare the surfaces produced by a milling machine (which is the favorite surface of bridge engineers) and by an oxy-acetylene cutting process, small bars, as nearly ⅜ in. square in cross section as it is possible to get, were cut from the steel plate and the I-beam web by these methods. A very smooth oxy-acetylene cut was secured by the use of a straight-line cutting machine. These little bars were then tested in bending in the standard fixture recommended by the American Weld-

ing Society, Fig. 2. The load is transmitted by a pin, equal in diameter to the thickness of the beam, and the edges of the supports are set just far enough to clear the bar when bent into a U. The testing machine records the amount of load needed to bend the bar up to its breaking point (or to a complete U-bend, if it doesn't break).

Placing the surface to be tested down, six bars from each specimen of steel were tested—three machined and three oxy-actylene cut, with the results given in the Table I.

TABLE I

MACHINED BARS
(No Fractures)

Steel Plate—
Load 1575 lb. Bent 180 degrees
Load 1575 lb. Bent 180 degrees
Load 1600 lb. Bent 180 degrees

Average 1580 lb.

I-Beam Web—
Load 1455 lb. Bent 180 degrees
Load 1425 lb. Bent 180 degrees
Load 1470 lb. Bent 180 degrees

Average 1450 lb.

OXY-ACETYLENE CUT BARS
(No Fractures)

Steel Plate—
Load 1725 lb. Bent 180 degrees
Load 1580 lb. Bent 180 degrees
Load 1700 lb. Bent 180 degrees

Average 1670 lb.

I-Beam Web—
Load 1605 lb. Bent 180 degrees
Load 1625 lb. Bent 180 degrees
Load 1640 lb. Bent 180 degrees

Average 1625 lb.

This tabulation, together with the view of the test pieces Fig. 3 shows that the oxy-acetylene cut surface is uniformly equal in ductility to the machine-cut surface, at least up to a 180-deg. bend, the most drastic test imposed by specifications. Furthermore, the oxy-acetylene cut-edges are considerably stronger and stiffer—it takes more load to bend them. Compare the average loads required:

	Machined	*Oxy-Acetylene Cut*
Steel plate	1580 lb.	1670 lb.
I-beam web	1450 lb.	1625 lb.

It appears, therefore, that the oxy-acetylene cut surface is stronger and stiffer, without being less tough and ductile, than the machined sur-

face. One suspects that the engineer who asks to have the flame-cut surface milled off from structural steel, is actually insisting on something not so good.

FIG. 5—ANGLE IRON; CUT WITH FRICTION SAW

Three small bars were sheared from the steel plate and tested. It was expected, of course, that these would show up rather poorly, as the shear undoubtedly damaged the metal for a certain distance below the surface. Results of these tests are shown in Table II.

TABLE II

SHEARED BAR

Steel Plate—

Load 1290 lb. Bent 43 degrees and cracked
Load 1280 lb. Bent 38 degrees and cracked
Load 1190 lb. Bent 31 degrees and cracked

Average 1250 lb. Bent 37 degrees and cracked

FRICTION SAWED BAR

Angle Iron—

Load 1840 lb. Bent 18 degrees and cracked
Load 1400 lb. Bent 24 degrees and cracked
Load 1610 lb. Bent 34 degrees and cracked

Average 1620 lb. Bent 25 degrees and cracked

Fig. 4 shows one of these bars after testing. From the results it is obvious that the sheared bars required only a fairly low load to bend up to the cracking point.

Next, bars were cut from an angle iron with friction saw and tested. Results of these tests are also given in Table II.

These results were rather unexpected. These bars were rather stiffer than the sheared bars, but it was found that the angle iron was somewhat different in chemical composition from the plate, and this accounted for this higher strength. However, the low ductility of the friction-cut surface was surprising. It actually required less bend to open up cracks than a sheared bar! (25 degrees bend against 37.) The suggestions that perhaps the steel was of low quality was disproved, because a bar machined

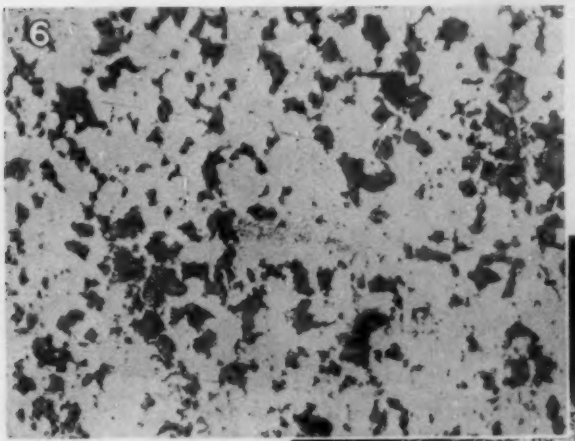


FIG. 6—MICROSCOPIC STRUCTURE OF HIGH GRADE STRUCTURAL STEEL. MAGNIFIED 100 DIAM.

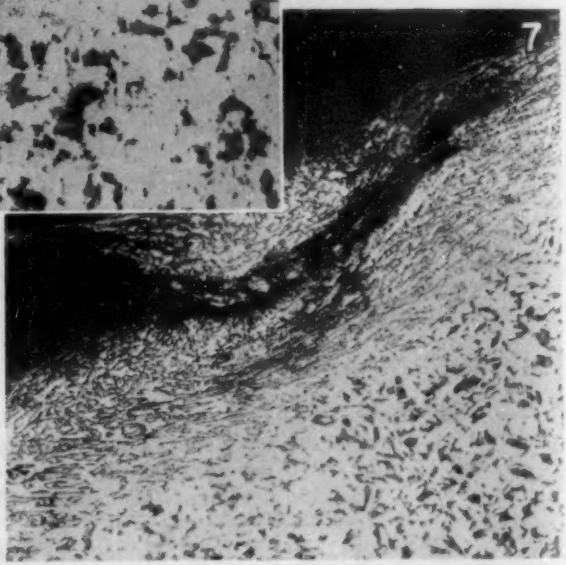


FIG. 7—SURFACE STRUCTURE AT FRICTION-SAW CUT. MAGNIFIED 100 DIAMETERS

from the angle iron bent 180 degrees without sign of trouble, under a load of 2,230 pounds.

It appears, therefore, that the friction-cut surface, although frequently accepted by structural engineers, is actually worse than the sheared surface.

Fig. 5 shows that friction sawing punishes the metal to a considerable extent. A heavy fin has been pushed up and adheres to the far edge. The near surface has a much smaller fin, but close examination shows a number of parallel grooves produced by the saw. Just what the effect

is may best be seen by a microscopical examination of the metal, as shown in Fig. 7.

For instance, Fig. 6 shows at 100 diameters magnification the structure of a first-class piece of steel plate.

The principal thing to notice is that the normal structure is low carbon steel is a heterogeneous mixture of very fine crystals.

Consider on the other hand, the extreme change wrought in this structure by the friction saw, Fig. 7. This view shows a slight sliver of metal all but torn off from the surface—a place where cracking will doubtedly

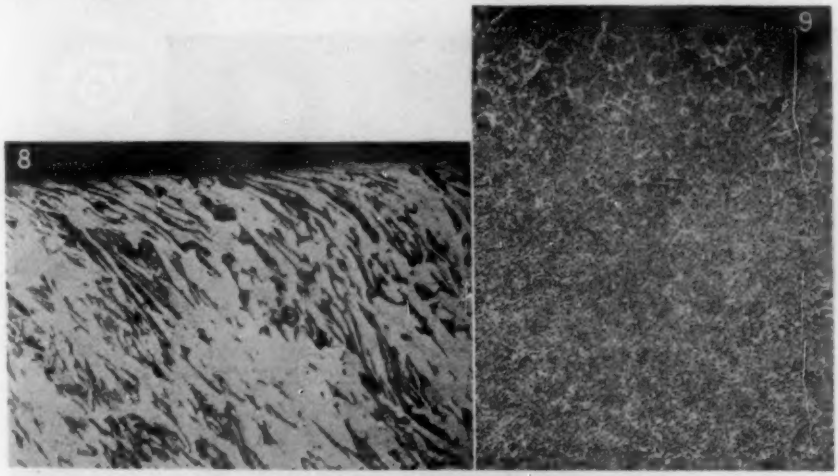


FIG. 8—STRUCTURE AT SHEARED SURFACE. MAGNIFIED 100 DIAM.

FIG. 9—OXY-ACETYLENE CUT SURFACE. MAGNIFIED 100 DIAM.

start. A thin layer just under the cut surface is also highly distorted; it seems to have "run like water." Underlying this (to the lower right-hand corner of the view) is a much finer grained mixture. Since the magnification of all these microphotographs is the same, that means that the heat and work of the friction saw has been sufficient to cause the metal to recrystallize into a much finer grain. This in itself is excellent; unfortunately the cracked, highly distorted surface far counteracts this effect.

A photograph taken through the microscope and at right angles to a sheared surface is shown in Fig. 8. The blades of the machine have squeezed the metallic crystals out into a streaky appearance, and there has been a well-marked flow of this plastic mass at the surface itself. Crushing of these grains does not extend very deeply into the material (remember that the actual surface represented by these photographs is about the size of a pin-head), but at the edge the distortion is very great. Usually shearing leaves a succession of tiny fins which serve as the starting point of cracks when the specimen is bent.

Quality of Oxy-acetylene Cut

The oxy-acetylene cut edge is far better than either of these. Fig. 9 shows that there is no distortion of the crystalline structure.

Figs. 6 and 9 give an adequate explanation of the added strength of a surface cut with an oxy-acetylene flame. There is abundant evidence that such a surface is not oxidized, as might be supposed from the fact that in a cutting flame hot metal actually burns or oxidizes in a stream of oxygen gas. This paradox is probably due to the fact that the iron seems to burn more readily than the carbon in the steel, and there is therefore a slight enrichment in carbon at the very edge. It is a matter of common knowledge that steel becomes harder and stronger as it

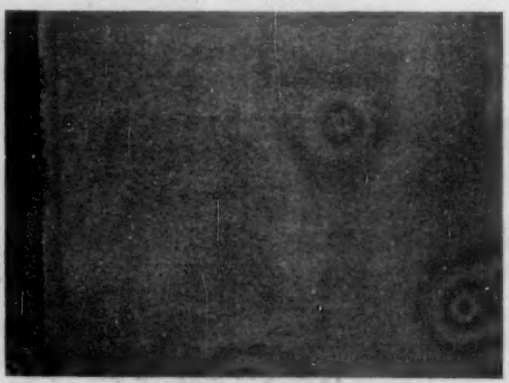


FIG. 10—PICKLED STEEL PLATE, OXY-ACETYLENE-CUT EDGE TO LEFT. NATURAL SIZE

analyses more and more carbon. Finally, this hot surface is chilled very quickly by the heat being absorbed into the cold metal behind. This is an effectual quenching. So the surface is not only hardened and strengthened by adding carbon; it is further hardened and strengthened by a quick quench from a high temperature.

However, if someone still retains any doubt of the quality of the acetylene-cut surface, and wishes to remove it, it is not necessary to cut away very much metal. Fig. 10 for instance, shows at full size a piece of the ⅜ in. plate cut along the left edge with a straight-line cutting machine. The surface photographed has been machined off, polished and pickled. Except at the beginning of the cut, where the flame was against the cold metal some time before starting, the heat effect is very uniform and extends just ⅛ in. into the metal.

A similar section made of the I-beam is shown in Fig. 11 at natural size. At the left is an oxy-acetylene cut, made by hand.

This photograph illustrates the depth to which the heat extends in oxy-acetylene cutting.

In order to check the assumption that the improvement made by oxy-acetylene cutting would be lost by removing ⅛ in. of metal, a series of

three tests was made on the ⅜ in. plate. The bars were cut ¼ in. oversize with a straight-line machine, and ⅛ in. from either edge milled off. Results are given in Table III.

TABLE III

CUT AND MACHINED BARS

Steel Plate—

Load 1600 lb. Bent 180 degrees (No fracture)
Load 1600 lb. Bent 180 degrees (No fracture)
Load 1550 lb. Bent 180 degrees (No fracture)

Average 1560 lb.

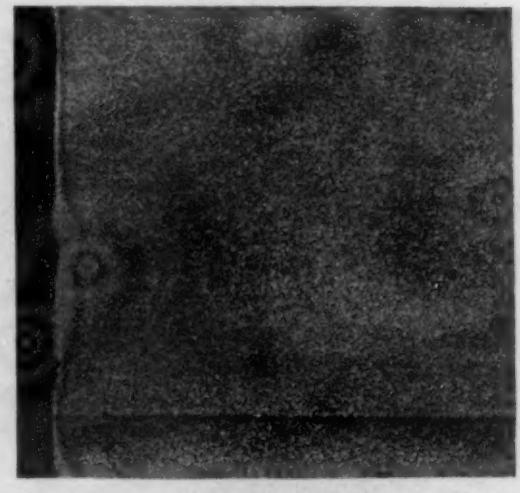


FIG. 11—AXIAL SECTION LOWER HALF OF I-BEAM, POLISHED AND HEAVILY ETCHED. OXY-ACETYLENE-CUT END TO LEFT

This is almost an exact check with the bars taken out of the plate with a machine tool noted in the first tabulation; they averaged 1580 pounds for a 180 deg. bend.

Thus it appears that there is nothing to fear from oxy-acetylene cutting on mild steel plate and structural shapes. Such a surface is in fact harder and stronger, yet equally ductile and tough as compared with the original metal. This heat effect and improvements is entirely removed by taking off ⅛ in. of the surface—that is, all that is necessary to reach unaffected and unchanged metal. A milled surface is thought to be almost the equal of the original metal. Further, it is demonstrated that a friction saw cut is even more damaging than a shear cut—either implement causing great distortion in the metal, and producing a surface having many minute tears which is a starting point for deep cracks when the metal is badly strained.

Announcement
New Design of Arc Welded Crane

A. F. DAVIS†

THE Cleveland Crane and Engineering Company, Wickliffe, Ohio, announces a new design of overhead traveling crane in which the bridge girders, end trucks and trolley are constructed by arc welding.

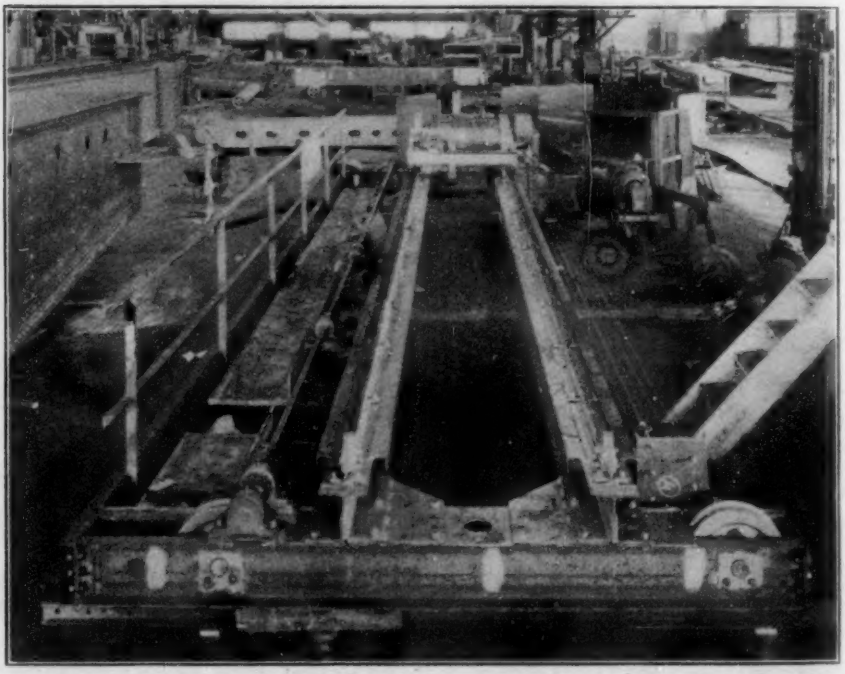


FIG. 1—NEW FIVE-TON 38 FT. 9¼ INCH SPAN CRANE OF THE I-BEAM GIRDER TYPE FABRICATED THROUGHOUT BY THE USE OF ARC WELDING

The illustration reproduced herewith shows a 5-ton, 38-ft. 9¼-in. span crane of the I-beam girder type. Each girder is reinforced throughout its entire length by angles arc welded to the standard I-beam sections. Riveted girders of similar construction would employ a channel section instead of the two angles. However, this extra material would not give as great strength or rigidity.

The girders are attached to the end trucks by the notched or shoulder construction designed to prevent weaving. To facilitate shipping the

†Vice-President, Lincoln Electric Co.

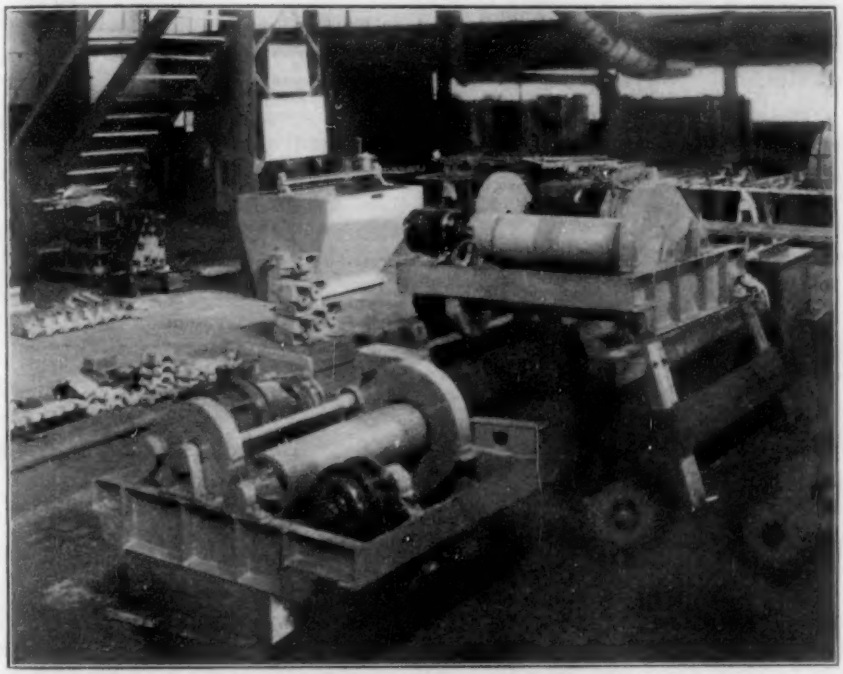


FIG. 2—COMPLETE ARC WELDED TROLLEY FRAMES OF NEW DESIGN OF ELECTRIC WELDED CRANE

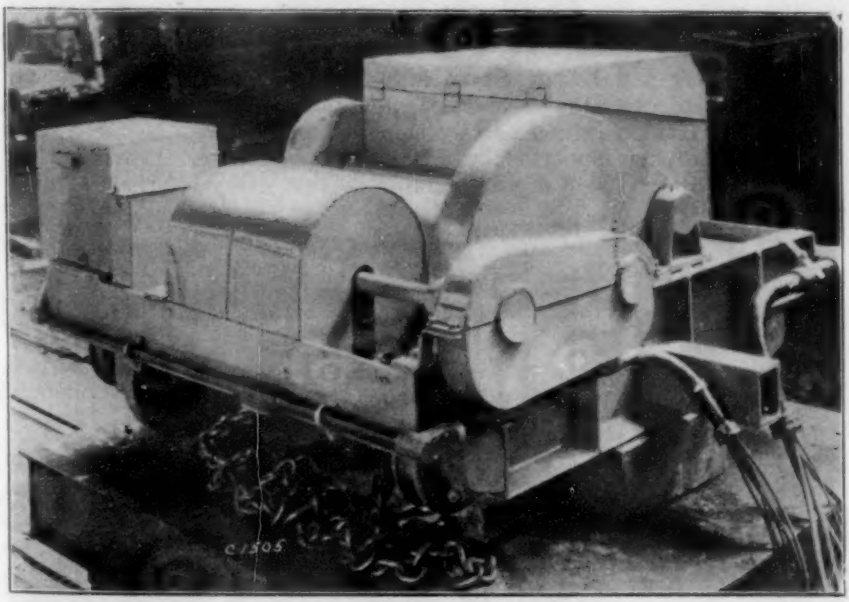


FIG. 3—ALL WELDED TROLLEY FRAME OF ARC WELDED CRANE, SHOWING COMPLETELY WELDED FRAME STRUCTURES AND GEAR GUARDS

girders and trucks are disassembled. The field connection is made by bolts but additional arc welded reinforcement is recommened to secure maximum rigidity.

The end trucks themselves are built up of two standard channel sections joined by arc welding. Roller bearings are used in this crane permitting rapid acceleration and lower power consumption.

Two small standard arc welded trolleys are illustrated. Each trolley frame is made of a standard channel with arc welded braces under each bearing point. Gear guards are arc welded as is also the hand rail on the foot bridge and the bearing supports for the bridge drive shafts.

The advantage claimed for arc welded crane construction, other than greater rigidity and strength, is that a more efficient distribution of weight is possible, thus making it possible to lighten certain moving parts and thereby to obtain greater acceleration.

Arc Welding Enters Commercial Building Field

A. F. DAVIS†

WORK was recently started on the first unit of a group of commercial buildings which will be erected on upper Carnegie Avenue, in the heart of Cleveland's fashionable up-town shopping district. The project which includes a twenty-story tower building is being promoted by the Austin Company, Cleveland, Ohio, nationally known architects and builders.

The building now being erected is a four-story structure which will house retail stores on the ground floor and offices on the remaining three floors. The front elevation as shown in the drawing will be faced with Indiana Limestone supported by a granite base course. Provision has been made in the design of the building so that every alternate column

†Vice-President, Lincoln Electric Co.

FIG. 4—FRONT ELEVATOR OF UPPER CARNEGIE BUILDING, FABRICATED ENTIRELY BY ARC WELDING

in the front of the store rooms can be removed thus making available at any time either 17 ft. or 34 ft. wide store fronts.

Intense interest is being displayed in the unique design and the construction methods employed in the fabrication and erection of the structural steel for the frame of the initial building. By the use of arc welding for making all connections, all punching and riveting are being eliminated in the shop fabrication of the structural members; field bolts and rivets are also eliminated from all connections being made in the field. Much favorable comment has been made by those situated near the scene of building operations on the absence of the deafening noise of riveting hammers heard on most steel erection jobs. Silent erection is fast becoming an important factor in favor of the arc welding process.

A design which permits such an innovation in construction methods cannot of course be based on the traditional designs of steel structures but rather must be founded on the possibilities of arc welding and the proven strength of welded connections. On this basis, the owners employed all the known economic advantages of arc-welded steel construction in designing the steel structure. The use of continuous beams instead of the usual multi-story columns is one of the unusual features in the design of the steel frame work.

The building is the first all welded steel structure to be erected in Cleveland and is the first commercial building so constructed in the entire country. It is probably the first structure whose owners have no connection with manufacturers of welding equipment.

The building was designed and is being erected by the owner, The Austin Company. The structural steel was fabricated in building owner's fabricating shop, the arc welding being done at the mill and in the field by The Lincoln Electric Company.

Ice Machine Design Marks Trend Toward Steel Construction

A. F. DAVIS†

A RADICAL departure from the traditional design of small capacity ice machines is shown in new ammonia refrigerating equipment recently put on the market by the Mansfield Ice Machine Company, Mansfield, Ohio. Regarded as one of the greatest single advancements in precision machine design that has been made in recent years this new ice machine ably demonstrates what can be accomplished with steel in standard shapes and at a cost considerably below the cost of cast iron construction.

In designing this machine the engineer disregarded all precedent and starting with a clean slate, has produced a machine which is thoroughly modern in every respect. Before a single part was even drawn

†Vice-president, Lincoln Electric Co.

up, the function of that part was thoroughly analyzed, then the part was designed in the simplest possible manner to meet the necessary requirements.

It is natural that the resulting design should differ in appearance from corresponding parts in machines of older design, since each part,

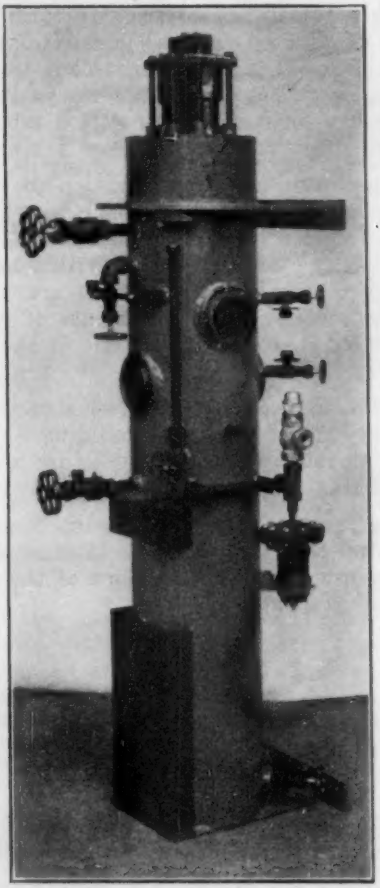


FIG. 1—PARTIALLY COMPLETED ALL WELDED COMPRESSOR

however, serves its function as well or better than parts designed to be manufactured in the conventional manner.

Methods of manufacture are factors that are equally important as the material used in making the improved design practical. By use of the electric arc welding process standard stock shapes of steel are made into machine parts that are lighter yet stronger and more serviceable than cast steel or iron. Economically, welded steel construc-

tion has a marked advantage over castings as it involves little overhead expense compared to that of maintaining a foundry, foundry equipment and patterns and pattern storage.

The advanced design of the Workrite ice machine was made possible only through the use of arc welded steel construction. The mechanical advantages resulting from the new design and construction are a reduction in size and weight, and higher compressor efficiency. The weight of the new machine is less than half of the weight of the best designed cast iron machine. The new unit occupies only 40 per cent of the floor space required by other ammonia refrigerating machines.

With the exception of the compressor pistons and the fly wheel the entire machine is made of steel. The connecting rods and crankshaft of the ammonia compressor are, of course, steel forgings, the balance of the parts being made from stock steel shapes such as round bars, plate, pipe, drawn seamless tubing and structural shapes.

By welding steel plates in the ends and the inside of a piece of 10 in. steel pipe 56 in. long the compressor housing and ammonia receiver for a refrigerating unit of 1100 lb. ice melting capacity is formed. Sections of drawn seamless tubing are arc welded together to form the removable cylinders of the compressor. The cylinder head is composed of two pieces of steel plate arc welded together. The removable head is held down by bolts screwed into threaded sections of round bar stock welded to the top of the crankcase. These arc welded items can be noted in the view, Fig. 1, of a partially completed machine. All the permanent pipe connections are also welded. The machine base and brackets and the motor base are built from standard structural shapes assembled by welding and attached to the shell by the same process.

The bearing ends of the compressor crankshaft are welded to the forging. Even the wrist pin connection end of the piston rods are sections of steel tubing welded to the forged rod. Another part which is built up by welding various pieces of steel together is the water tight housing of the condenser coils mounted on the top of the machine.

Credit for the ingenious design and construction of the new type automatic ice machine should be given to M. H. Ackerman, president of the Mansfield Ice Machine Company, who conceived the widespread possibilities of the use of arc-welded steel construction in the manufacture of his company's products.

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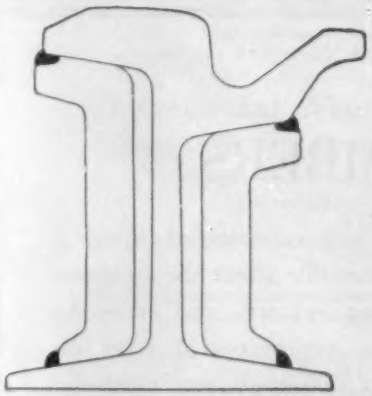

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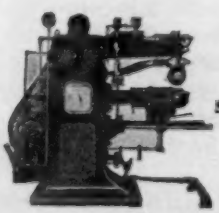
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"Here, Lad—

Your argument that we should place our orders for arc welders with Lincoln because they're welding *specialists* doesn't hold water.

If Lincoln made a thousand other electrical items they would still have specialists in the welding department."

Only "Stable-Arc" Welders have all these features

Variable Voltage.
Laminated Magnetic Circuit.
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Steady Arc Throughout Entire Welding Range.
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Full Capacity for either Metallic or Carbon Arc Welding.

These features make welding easier. Results — better welds and greater output.

Ask any Operator!

"Yes, Pop—

but go to 'specialists' like that with a problem that requires executive attention or deviation from standard practice and see where you get off.

But when the whole thought of the whole organization is arc welding, as with Lincoln—you get your answer in five minutes—that's all they talk about.

When you traded in your auto last week you went to an agency where you could talk to someone in authority and settle the deal to your best advantage.

Even if all makes of welders were equally good (see left panel), I'd still say, 'go to Lincoln' with your welding problem because you can call them on the 'phone and get the deal settled with the receiver to your ear.

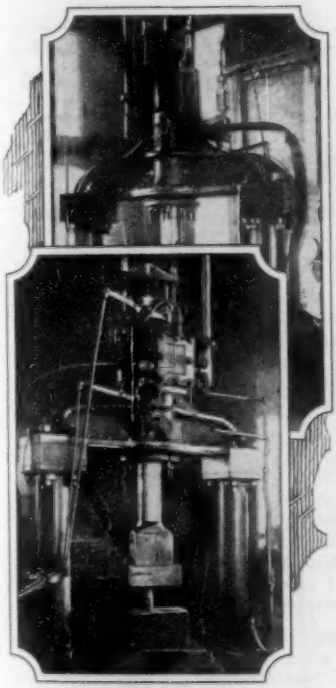
The only red tape in the Lincoln plant is that used to tie rush shipping tags on 'Stable-Arc' welders."

The Lincoln Electric Co., Dept. No. 22-11, Cleveland, Ohio

W-11.

"Stable-Arc"
LINCOLN WELDER

Giant Steam Hammer
in Railway Shop
Welded with Tobin Bronze



Front and back views of repaired steam hammer.

THIS steam hammer, in the Algiers, La., blacksmith shop of the Southern Pacific Lines, operates a weight of 1100 pounds. In February, 1927, the cylinder cracked as indicated by the white lines in the photographs.

The breaks were all repaired with Tobin Bronze welding by the oxy-acetylene process, and the hammer has been in operation ever since, as sound and strong as ever.

It would probably have caused a delay of thirty days to construct a pattern, and make and finish a new casting. With Tobin Bronze Welding twelve hours of a machinist's time and sixteen of a welder's were required. Fifty pounds of Tobin Bronze Welding Rods, 400 feet of acetylene and 600 feet of oxygen were used.

This is a typical example of how Tobin Bronze welding saves time and cuts down costs, both in repair work and in manufacturing operations.

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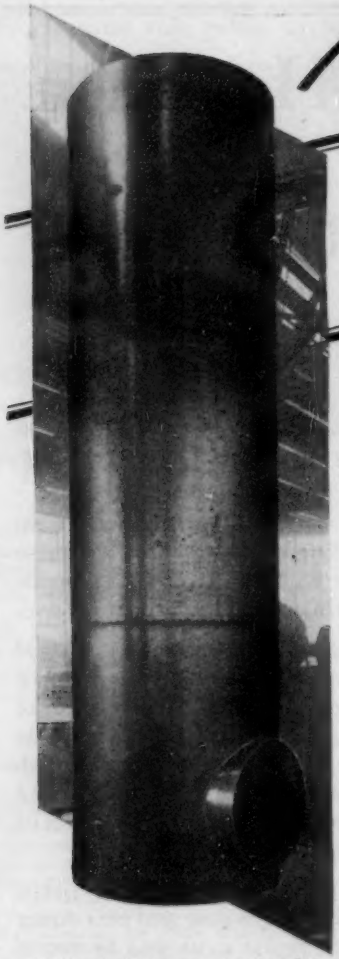

Nitric Acid Tower, fabricated from Chrome Alloy plates by means of electric welding. These all-welded tanks are being produced by Industrial Welded Products Co., Inc., Newark, N. J., who use Wilson Machines exclusively.

NOW they're ELECTRIC WELDED!

NITRIC ACID TOWERS

made of Chrome Alloys

Are Being ELECTRIC WELDED

with *Wilson Machines*

HERE is one of the Nitric Acid Towers, made of non-corrosive chrome alloy, which Industrial Welded Products Co., Inc., Newark, N. J., is fabricating entirely by *electric* welding—and *exclusively* with Wilson Welding Machines! The welds in these tanks not only exhibit extraordinary strength and ductility, but also show *resistance to corrosion equal to the chrome alloy plates which they join!*

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"I've told you about him. He's the Linde Service Operator," replied the master mechanic. "This morning he was working with our welders on repairing that big casting. I don't know what he's working on over there. Probably he's telling Tom some new welding wrinkle. Anyway, I'll bet it shows up as a saving of some kind in our costs."

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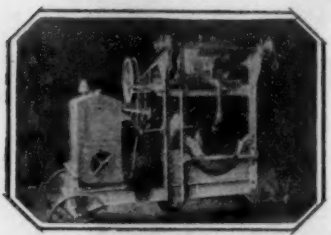

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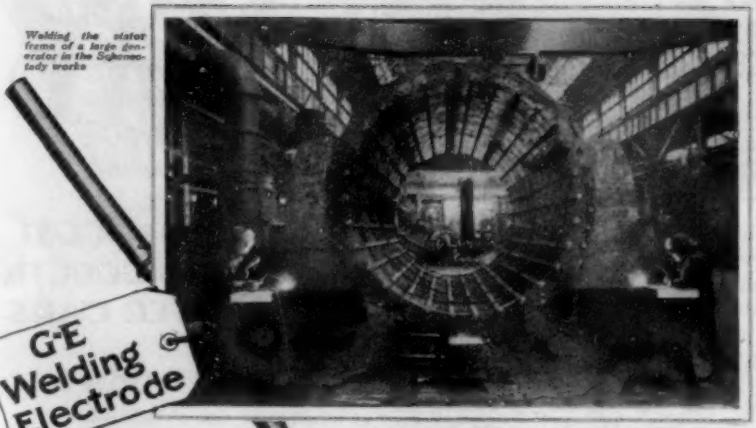

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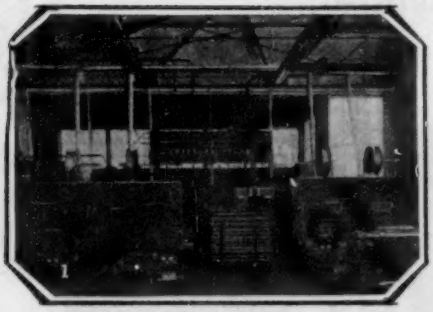

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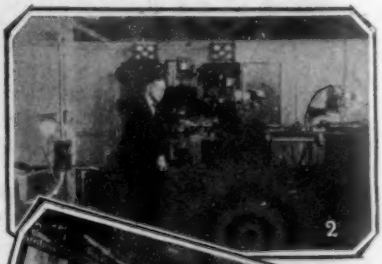

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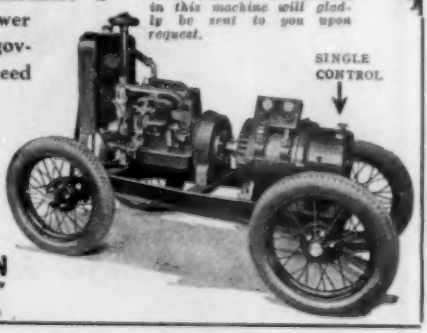

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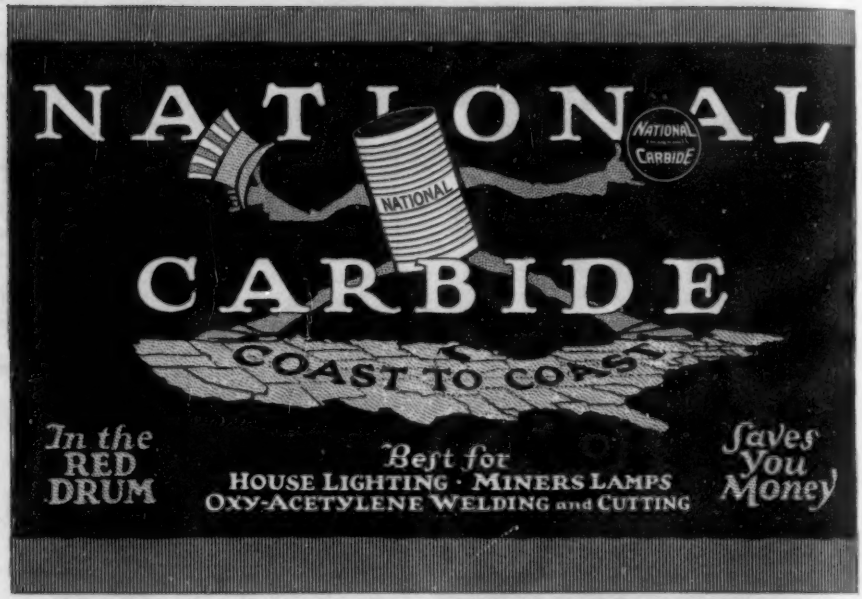

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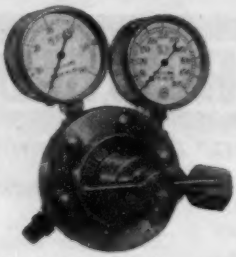

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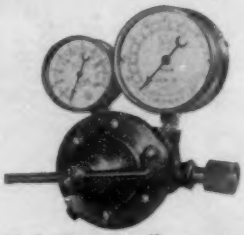

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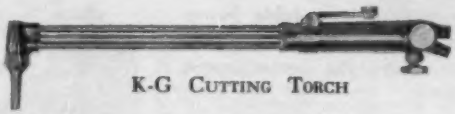

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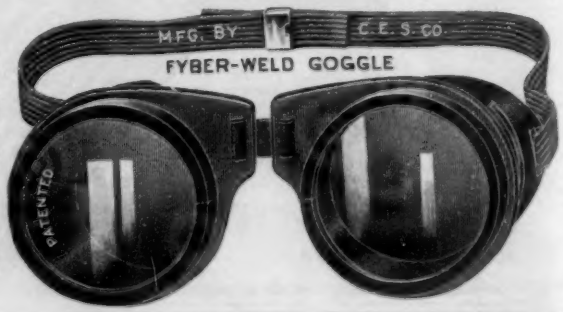

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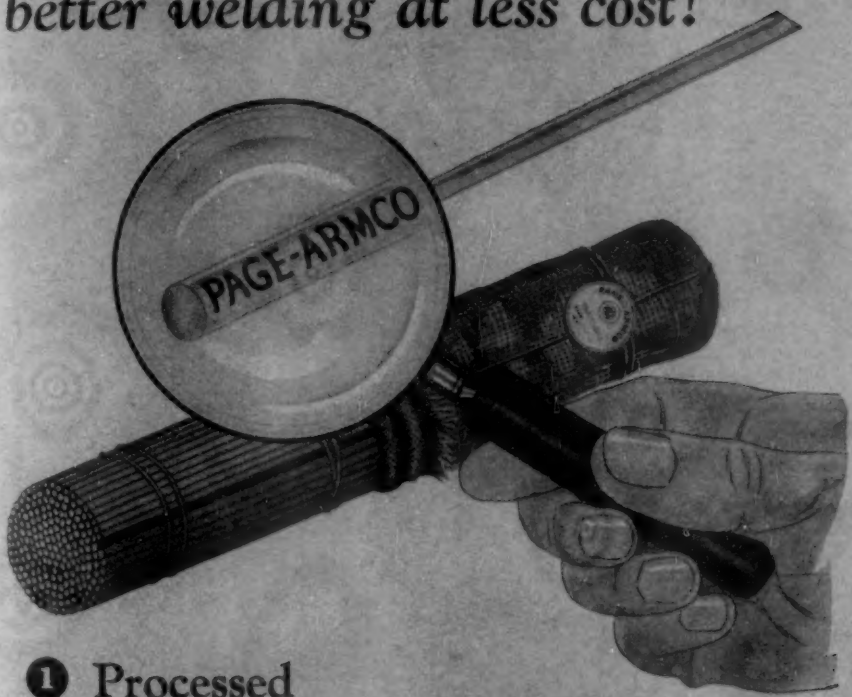

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